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Pilot Project for Evaluating the Segway™ HT Motorized Personal Transportation Device in Real Conditions

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Centre d'expérimentation des véhicules électriques du Québec

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by
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16. Abstract

This report contains the findings of the pilot project for evaluating the Segway™ HT Electronic Personal Assistive Mobility Device (EPAMD) conducted by the Centre for Electric Vehicle Experimentation in Quebec (CEVEQ). The evaluation plan was in two stages. The first was conducted on a closed circuit, with 49 users, for purposes of technical and ergonomic evaluation. The second phase consisted of experimentation under actual operating conditions on public roadways and involved 143 users, in three cities, who covered more than 9,000 km.

The study focused on EPAMD users' perception of safety, but also on how safe the Segway seemed to pedestrians, cyclists and motorists who came in contact with it. In addition, the evaluation looked at these devices' reliability, social acceptability and safety when used in an urban environment, as well as potential applications to foster intermodality.

The evaluation results led, in particular, to a recommendation that EPAMDs be permitted to operate in urban pedestrian areas and be subject to regulations based on the proposed traffic standards.

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16. Résumé

Ce rapport contient les résultats du projet pilote d'évaluation portant sur l'appareil de transport personnel motorisé (ATPM) Segway HT mené par le Centre d'expérimentation des véhicules électriques du Québec (CEVEQ). Le plan d'évaluation comportait deux phases. La première s'est déroulée en milieu fermé, a impliqué 49 usagers et a vu la réalisation d'une étude technique et ergonomique du Segway. La deuxième phase a consisté en une expérimentation en conditions réelles d'utilisation sur la voie publique et a impliqué 143 usagers qui ont parcouru plus de 9 000 km dans trois villes.

Cette étude a notamment permis d'évaluer la perception de sécurité des utilisateurs des ATPM, mais aussi celle des piétons, des cyclistes et des automobilistes qui ont côtoyé le Segway. De plus, cette évaluation a porté sur la fiabilité, l'acceptabilité sociale et la sécurité de ces appareils lorsqu'ils sont utilisés en milieu urbain ainsi que sur les applications potentielles en faveur de l'intermodalité.

À la suite des résultats obtenus des évaluations, il est notamment recommandé qu'il soit permis de circuler dans les zones piétonnières urbaines avec un Segway, en observant des règlements inspirés des normes de circulation proposées.

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Foreword

During 2005, we became aware of many extreme meteorological events. A number of studies have shown a link between human activity and global warming. A consensus has emerged at the international level on the importance of taking action to cut greenhouse gas (GHG) emissions, as evidenced by the coming into force of the Kyoto Protocol in February 2005, the Eleventh Session of the Conference of Parties (CoP-11) to the United Nations Framework Convention on Climate Change (UNFCCC), and the first Meeting of the Parties (MoP-1) to the Kyoto Protocol held in Montreal from November 28 to December 9, 2005.

As regards transportation, which accounts for nearly 25 percent of all GHGs in Canada and 38 percent in Quebec—and these percentages are rising—implementation of technological solutions is slow. Solutions to reduce our dependency on fossil fuels do exist, but they need to be encouraged and given a higher profile if they are to become truly available, and if the emergence of sustainable transportation is to be promoted.

Summary

In 2003, the Centre for Electric Vehicle Experimentation in Quebec (CEVEQ), in partnership with the Quebec Department of Transport (MTQ) and Transport Canada, carried out the first phase of a pilot project to evaluate the Segway™ HT Electronic Personal Assistive Mobility Device (EPAMD) and an electric scooter. The evaluation plan was in two stages: driving tests were conducted first in a closed environment, then under actual conditions of use. This approach was intended to enable the safety aspects to be better understood before experiments were done on public roadways.

The work of phase 1 consisted of a review of the literature on pilot projects involving electric scooters and EPAMDs, production of a summary report on these studies, and an analysis of existing safety regulations, legal provisions for use of these devices, traffic rules and incidents recorded. In parallel with this work, CEVEQ, supported by expert groups, carried out an ergonomic, technical and operational evaluation of the EPAMD in closed-circuit testing inside a large building. For safety reasons, the Quebec Automobile Insurance Board (SAAQ) wanted a closed-circuit evaluation to be done before any experimentation on public roadways. This evaluation also included a user survey component to canvass users' reactions to any difficulties that had arisen and their points of view on the safety and potential usefulness of EPAMDs.

Following the tabling of the phase 1 report, MTQ and SAAQ indicated they were in favour of conducting a second phase of evaluation, under certain conditions, of the Segway EPAMD alone. The authorities did not consider the electric scooter safe enough for experimentation on public roadways.

Phase 2 of the project was, therefore, concerned only with Segway EPAMDs. The study was conducted during the summer and autumn of 2005 on the kinds of pedestrian pathways for which the Segway was designed: sidewalks, bicycle paths and roadway shoulders with speed limits of 50 km/h or less.

The purpose of this second phase, carried out in accordance with the recommendations of the phase 1 final report, was to observe:

- how these EPAMDs interacted with pedestrians in the various pedestrian areas, thus making it possible to assess the Segway's social acceptability;
- how safe the Segway is in urban areas;
- the effects of a dynamic environment – crossing intersections, various lighting conditions (day/night), various weather conditions (wind, rain, cold), etc. – on the use of Segway EPAMDs.

Conclusions

Evaluation of the Segway EPAMD was carried out in two phases. The first was conducted in a closed-circuit environment, with 49 users, for purposes of technical and ergonomic evaluation. The second phase consisted of experimentation under actual conditions of use on public roadways and involved 143 users who covered more than 9000 kilometres in three cities.

The following conclusions were arrived at with regard to the project objectives:

1. SAFETY

a) During phase 1, technical testing results showed that in normal conditions of use, the Segway HT is stable, operates smoothly and gives the user a feeling of control.

b) Ergonomic evaluation also showed that the Segway is easy to use in normal conditions, even when surmounting obstacles, for a very broad range of users. The device compares well to other types of vehicle, particularly with respect to stability and ease of learning, where it proved superior to other vehicles such as bicycles or mopeds.

c) The 3.5-hour training period, provided and strongly recommended by the manufacturer, does offer the necessary initiation for the safe use of the Segway on public roadways.

d) Training/initiation in Segway use, the user's age/maturity, and the wearing of a helmet all contribute to safer use of the Segway EPAMD.

e) The perception of the Segway as dangerous and the apprehensions prevalent in the minds of the selected candidates and the CEVEQ team faded away after one week's experimentation with driving the Segway and as the project advanced.

f) No incident or serious injury, nor any Segway/pedestrian collision or physical interference, was reported during either of the two phases of evaluation, where distances totalling more than 9,000 km were covered. The only incidents reported involved the user only. The frequency of such incidents may diminish as users gain driving experience.

g) During experimentation under actual conditions of use, in phase 2, it was found that a significant distinction needs to be made between safety aspects and those concerning the EPAMD's acceptability.

h) The feeling of insecurity expressed by users generally arose from their lack of confidence in being able to properly control the device under difficult conditions, such as encountering a pedestrian or navigating tight spaces and difficult surfaces, conditions which often exist on sidewalks. Most likely, with more driving experience, their confidence will improve, as when learning to ride a bicycle.

i) Among interactors, and in particular in the case of pedestrians on sidewalks, perceptions were a blend of safety concerns and the nuisance factor. The latter seems to be a greater concern than safety, since no incident or serious injury was reported in the course of 9000 km of testing by users with little driving experience. The level of nuisance felt was most probably exacerbated by the exceptionally large concentration of Segways and pedestrians that were interacting. Under normal conditions of use, the nuisance factor should diminish significantly.

j) EPAMDs driven on sidewalks, cycle paths and roadway shoulders where speed is limited to 50 km/h will have little impact on user safety and still less on the safety of pedestrians, cyclists, motorists and other walkway users.

2. ACCEPTABILITY

Sidewalks were the only type of walkway where the acceptability of EPAMDs was at all in question. EPAMD traffic was found quite acceptable on cycle paths and roadway shoulders.

3. STANDARDS OF USE

a) The manufacturer's recommendation is that 16 be the minimum age required for use of this EPAMD on public roadways.

b) Most users perceive helmets to be necessary for safety. They should, therefore, be required.

c) Considering that Segway driver training involves about the same degree of complexity as learning to ride a bicycle and that the manufacturer, through its distributors, ensures that the first-time purchaser receives a 30-minute initiation, formal training does not seem necessary.

d) Study limitations prevented night use of EPAMDs from being properly evaluated. Users' experience nonetheless suggested that under such conditions, EPAMDs would be as safe as bicycles as long as they were fitted with a headlight.

4. EPAMDS AS AN ALTERNATIVE VEHICLE

There was quite a bit of interest in Segways for short trips in urban settings; this would generate a certain amount of transportation shifts, particularly away from automobiles. At the current price of the Segway device, however, few of the users surveyed were ready to buy one.

Recommendations

1. Considering the Segway's very positive environmental qualities and insignificant negative impacts, apart from its possible nuisance value on sidewalks, its use on urban walkways should be allowed. Such use should be subject to regulations patterned after the suggested traffic standards.

2. Municipal authorities should be authorized to limit Segway traffic in areas or during periods they deem inappropriate.

3. Guidelines should be prepared for municipalities to inform them of measures to be taken to promote safe and trouble-free EPAMD traffic within their boundaries.

4. A public awareness campaign should be undertaken to allay fears and apprehensions among pedestrians with respect to EPAMD use on sidewalks and to promote the environmental benefits of their use.

5. Information on the rules of use for Segway drivers should be made available.

6. Canadian and US experience in the use of Segways should be monitored and standards of use adjusted accordingly.

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Glossary and Abbreviations

EPAMD[1]
Electronic Personal Assistive Mobility Device. Defined as an electrical device, other than a medical device or an all-terrain vehicle, with two wheels and a self-balancing platform, designed to be driven in a standing position, whose maximum speed is not in excess of 20 km/h. The acronym EPAMD used in drafting this report refers only to the Segway™ Human Transporter (Segway HT or Segway).

CEVEQ
Centre for Electric Vehicle Experimentation in Quebec

Interactors
By "interactors" are meant all persons (pedestrians, cyclists, motorists) who use sidewalks, bicycle paths and road shoulders at speeds of 50 km/h or less in the study areas, other than Segway HT users, and who have agreed to fill out a questionnaire.

Interaction
An artificial increase in the concentration of EPAMD users in order to evaluate their co-existence with pedestrians, cyclists and motorists.

Intersection
An area where a road intersects with a sidewalk or bicycle path, accommodating pedestrian, bicycle and automobile traffic.

Pedestrian
Any person going on foot in a pedestrian zone. Includes persons moving through this zone in wheelchairs, strollers, on bicycles or inline skates.

SAAQ
Société de l'assurance automobile du Québec

Users
Users of the Segway HT.

Pedestrian zones
These include sidewalks, bicycle paths, intersections and the shoulders of roads where speed limits of 50 km/h or less are posted.

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[1] Definition adapted by CEVEQ from the literature (US standards, municipal and state legislation). The first step toward approval of the Segway HT on sidewalks was the June 2002 legislation on its use on sidewalks under federal jurisdiction. This legislation (Senate bill S. 2024) defined the Segway HT as an "*Electric Personal Assistive Mobility Device*" (EPAMD), distinguishing it from other new vehicles such as electric scooters. Subsequently, many US states, using the same acronym or the term "*Personal Motorized Mobility Device*" enacted legislation exempting the Segway HT from the regulatory framework governing motor vehicles and similar products. The NHTSA (National Highway Transportation Safety Administration), a US Department of Transportation agency with the responsibility of setting and enforcing safety standards for motor vehicles, and the US Consumer Product Safety Commission (CSPC) also recommended that the Segway HT be regulated as a consumer product.

1. BACKGROUND

1.1 INTRODUCTION

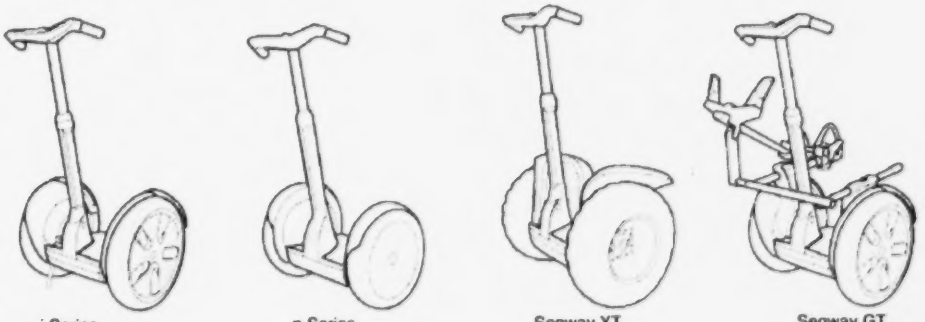
Transportation and freight are growing exponentially. The negative effects of mobility (dependence on fossil fuels, pollution in all its forms, greenhouse gases, congestion, etc) are well known and documented, and most governments concede the urgency of acting to find ecologically sound solutions.

Differing visions of possible solutions lie at the heart of the worldwide debate on these matters. One vision—call it a techno-fix—is based on the concept of the hypercar, an ultra-light, ultra-streamlined vehicle driven by a hybrid electrical system consuming up to 10 times less fuel than a conventional car. Another vision sees public transit as the basis for any sustainable solution. In the quest for replacement systems, Electronic Personal Assistive Mobility Devices (EPAMDs) may contribute to a modal shift away from cars for short-range trips. Electric scooters and the Segway™ are perceived as trendy and "green" devices for effortless jaunts in an urban context. Legislatures, concerned with the congestion of public roads, particularly in larger urban centres, as well as safety issues, initially had a cautious reaction to EPAMDs, the more so in that their co-existence with road users and pedestrians did create some controversy.

1.1.1 Description of the Device

Now called the *Segway Human Transporter*, after originally being known by the code names "IT" and "Ginger", the Segway was rolled out with much hoopla in December 2001 in the United States. It is described as "the first self-balancing electric-powered personal transportation device". Though accurate statistics are unavailable, some tens of thousands of these EPAMDs are now in use worldwide.

The idea for the Segway came from the "Ibot", a revolutionary six-wheeled wheelchair that allows persons with disabilities to climb stairs without losing their balance. The device was originally called "Fred" by its inventor, Dean Kamen, President of Segway LLC. Currently, the Segway LLC company offers two platforms and five models: the i 167 (series i), the e 167 (series e), the p 133 (series p), the Segway HT (offroad), and the Segway GT (golf).



Model:	i Series	p Series	Segway XT	Segway GT
Dimensions:	48 x 64 cm	41 x 55 cm	53.3 x 77.5 cm	53.3 x 77.5 cm
Weight:	38 kg	32 kg	45.4 kg	43 kg
Range:	13-39 km	10-13 km	13-16 km	16-35 km
Maximum speed:	20 km/h	16 km/h	20 km/h	20 km/h

Figure 1 – Four of the five Segway models

The Segway is started with a coded key that stores the user's settings and is difficult to counterfeit. Each device has three smart keys that enable users to adapt their driving style to their experience and the prevailing conditions. The "learning" mode (maximum speed of 8 km/h, slow turns) allows users to acquaint themselves with the vehicle and gain confidence. The "pedestrian" mode (maximum speed

12 km/h, medium-speed turns) is suited to a pedestrian environment. Finally, the "open space" mode (maximum speed of 20 km/h and sharp turns) is for use in open spaces.[2]

The Segway maintains its own balance and that of its passenger. The Segway has a fixed T-shaped handle set on a platform with two wheels side by side; it is driven in a standing position and manoeuvred by body movements: lean forward to go, stand up to stop, and lean back to reverse. The device has no brakes or accelerator, and is equipped with just a handle for turning. It is the only vehicle that can turn in place, like a pedestrian, thanks to the ability of its wheels to counter-rotate.

The Segway's operation is continuously analyzed by its built-in microprocessors. Five gyroscopes and two sensors work together to determine its position relative to its centre of gravity. The on-board computers analyze the measurements from these devices and compensate for ground irregularities in real time to adjust vehicle movement and ensure the user a stable ride. Maximum range is 39 km under ideal conditions (Li-ion batteries, level ground, no wind, smooth pavement, correct tire pressure, etc.) or between 13 and 16 km under normal conditions of use (NiMH batteries). Series i and e Segways weigh 38 kg and can be folded to fit into a car.

At 31 kg, the Segway series p is the lightest, most portable model in the range. It has smaller wheels and a narrower platform than the other models. The Segway series p has a maximum speed of 16 km/h. To begin with, this Segway model was sold to consumers in test markets; it is considered a short-range transportation solution and has been available on the US market since October 2003.

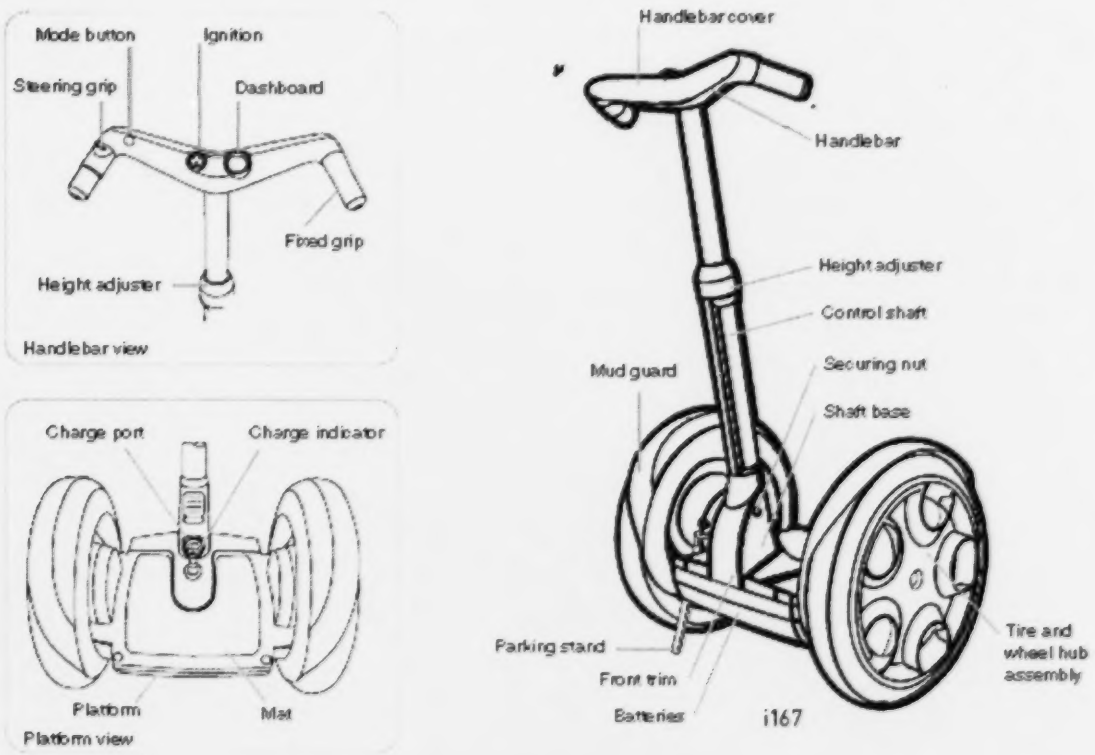


Figure 2 – Annotated view of the Segway HT

[2] www.segway.com

1.1.2 Status of Regulations

In February 2006, 42 US states and the District of Columbia[3] enacted regulations authorizing Segway use on sidewalks, bicycle paths, and some roads. In Europe, the Segway HT is permitted in practically all countries except England, Switzerland, Holland, Belgium, Spain and in the Scandinavian countries (Sweden, Norway, Denmark and Finland) where evaluations are in the works.

In Canada, EPAMDs—electric scooters and Segways—are not allowed to travel on public roads and sidewalks. Transport Canada, which is in charge of setting safety standards for motor vehicles for road use, deems the Segway not to be such a vehicle and, therefore, not subject to the *Canada Motor Vehicle Safety Act*. It is, therefore, up to the provinces to decide whether the Segway HT is suited to public roads.

The Ontario Ministry of Transportation (MTO), in a publication entitled "Two and Three-Wheeled Vehicles in Ontario", available on the MTO website,[4] states that the Segway cannot be operated on roads in Ontario. The Ministry explains that this device is not included as a vehicle intended for on-road use under the *Motor Vehicle Safety Act*. It is considered a device for the pedestrian environment. The MTO advises anyone using a Segway to contact local municipalities to determine whether the machines are allowed on sidewalks.

The Ontario municipality of London, for example, has permitted mobility-impaired persons to use Segway HT EPAMDs on its sidewalks and bicycle paths since October 2005.[5] In Toronto, City Council has recommended that the City of Toronto recognize the Segway only as a mobility aid.

Table 1 – Regulatory requirements for Segway HT use in the United States

State	Allowed on sidewalks and bicycle paths	Allowed on roadways	Helmet mandatory	Age limit	Legislation on pedestrians applies
Alabama	Sidewalks and bicycle paths	Yes	--	--	--
Alaska	Sidewalks and bicycle paths	Yes	No	--	--
Arizona	Sidewalks	Yes, if there are no sidewalks	No	16	Yes
Arkansas	--	--	--	--	--
California	Sidewalks and bicycle paths	Yes	No	--	Yes
Colorado	--	--	--	--	--
Connecticut	Sidewalks	No	No	16	--
Delaware	Sidewalks and bicycle paths	Yes, on roads posted 48 km/h or less	Under 16	--	--
District de Columbia	Sidewalks	--	No	16	--
Florida	Sidewalks and bicycle paths	Yes, on roads posted 40 km/h or less	Under 16	--	--
Georgia	Sidewalks	Yes, on roads posted 55 km/h or less	Under 16	16 (on road)	Yes
Hawaii	--	--	--	--	--
Idaho	Sidewalks	--	No	--	Yes
Illinois	Sidewalks	Yes	No	--	Yes
Indiana	Bicycle paths	Yes	No	--	--
Iowa	Sidewalks and bicycle paths	No	No	16	--
Kansas	Sidewalks	Yes	No	--	Yes
Kentucky	--	--	--	--	--
Louisiane	--	--	--	--	--
Maine	Sidewalks and bicycle paths	Yes, on roads posted 55 km/h or less, if there are no bicycle paths or sidewalks	No	--	--
Maryland	Sidewalks	Yes, on roads posted 48 km/h or less, if there are no sidewalks	Under 16	--	--

[3] www.segway.com
[4] http://www.mto.gov.on.ca/french/dandv/vehicle/emerging/index.html
[5] Streets By-Law, S-1 Consolidated – October 3, 2005, Council of the City of London, Ontario, Canada.

State	Allowed on sidewalks and bicycle paths	Allowed on roadways	Helmet mandatory	Age limit	Legislation on pedestrians applies
Massachusetts	--	--	--	--	--
Michigan	Sidewalks	Yes, on roads posted 40 km/h or less	No	--	--
Minnesota	Sidewalks and bicycle paths	Yes, on roads posted 55 km/h or less, if there are no sidewalks	No	--	Yes
Mississippi	Sidewalks and bicycle paths	Yes, wherever bicycles are permitted	No	--	--
Missouri	Sidewalks and bicycle paths	Yes, on roads posted 70 km/h or less	No	16	Yes
Montana	--	--	--	--	--
Nebraska	Sidewalks and bicycle paths	Yes, except on throughways and Interstates	No	--	--
Nevada	Sidewalks and bicycle paths	--	No	--	Yes
New Hampshire	Sidewalks	Yes	No	--	--
New Jersey	Sidewalks and bicycle paths	Yes	Yes	16	--
New Mexico	Sidewalks and bicycle paths	Yes	No	--	Yes
New York	--	--	--	--	--
North Carolina	Sidewalks and bicycle paths	Yes, on roads posted 40 km/h or less	No	--	Yes
North Dakota	--	--	--	--	--
Ohio	Sidewalks, unless reserved for the exclusive use of pedestrians and bicycles	Yes, on roads posted 80 km/h or less	Under 18	14	--
Oklahoma	Sidewalks and bicycle paths	Yes, on city streets	No	16	Yes
Oregon	Sidewalks and bicycle paths	Yes, on roads posted 55 km/h or less	No	--	--
Pennsylvania	Sidewalks, except where unlawful under local jurisdiction	Yes, except on throughways	Under 12	--	--
Rhode Island	Sidewalks and bicycle paths	Yes, except where bicycles are prohibited on the roadway	No	16	--
South Carolina	Sidewalks	Yes, if there are no sidewalks	No	--	--
South Dakota	Sidewalks	--	No	--	Yes
Tennessee	Sidewalks and bicycle paths	Yes	No	--	--
Texas	Sidewalks and bicycle paths	Yes, on roads posted 48 km/h or less, where there are no sidewalks.	--	--	--
Utah	Sidewalks	Yes, on roads posted 55 km/h or less, and with fewer than 4 lanes	Under 18	16	--
Vermont	Sidewalks and bicycle paths	No	No	16	Yes
Virginia	Sidewalks, except where unlawful under local jurisdiction	Yes, on roads posted 40 km/h or less, and if there are no sidewalks	Under 15	14	--
Washington	Sidewalks and bicycle paths	Yes, but not on controlled-access roads	No	--	--
West Virginia	Sidewalks	Yes	No	--	Yes
Wisconsin	Sidewalks, except where unlawful under local jurisdiction	Yes, but the municipality may prohibit them on specific roads or on roads posted 40 km/h and up	No	--	No
Wyoming	--	--	--	--	--

Source: Project Fly-Trottel 1, *Pilot project for evaluating motorized personal transportation devices: Segways and electric scooters*, TP 14285E, Final report, May 2004, CEVEQ.

1.2 REVIEW OF EVALUATION, PHASE 1

In 2003, CEVEQ, in partnership with the Quebec Department of Transport (MTQ) and Transport Canada, carried out the first phase of a pilot project to evaluate the Segway HT Electronic Personal Assistive Mobility Device (EPAMD) and an electric scooter. The evaluation plan was in two stages: driving tests were conducted first in a closed environment, then under actual operating conditions. This approach was

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Minnesota	Sidewalks and bicycle paths	Yes, on roads posted 55 km/h or less, if there are no sidewalks	No	--	Yes
Mississippi	Sidewalks and bicycle paths	Yes, wherever bicycles are permitted	No	--	--
Missouri	Sidewalks and bicycle paths	Yes, on roads posted 70 km/h or less	No	16	Yes
Montana	--	--	--	--	--
Nebraska	Sidewalks and bicycle paths	Yes, except on throughways and Interstates	No	--	--
Nevada	Sidewalks and bicycle paths	--	No	--	Yes
New Hampshire	Sidewalks	Yes	No	--	--
New Jersey	Sidewalks and bicycle paths	Yes	Yes	16	--
New Mexico	Sidewalks and bicycle paths	Yes	No	--	Yes
New York	--	--	--	--	--
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intended to enable the safety aspects to be better understood before experiments were done on public roadways.

The work of Phase 1 consisted of a review of the literature on pilot projects involving electric scooters and EPAMDs, production of a summary report on these studies, and an analysis of existing safety regulations, legal provisions for use of these devices, traffic rules and incidents recorded. In parallel with this work, CEVEQ, supported by expert groups, carried out an ergonomic, technical and operational evaluation of the EPAMD in closed-circuit testing inside a large building. For safety reasons, the Quebec Automobile Insurance Board (SAAQ) wanted a closed-circuit evaluation to be done before any testing on public roadways. This evaluation also included a user survey component to canvass users' reactions to any difficulties that had arisen and their points of view on the safety and potential usefulness of EPAMDs.

1.2.1 Findings of Segway Evaluation, Phase 1

The results of the technical evaluation carried out at the PMG Technologies Test and Research Centre demonstrated that, under normal use, Segways are very stable, run quietly and smoothly, and give users a feeling of being in control. They are easy to manoeuvre, accelerate gently, run silently and can stop quickly in case of emergency. Users are informed immediately of any loss of pressure in a tire by the device's slight veering to the side of the deflated tire. The device easily goes up and down hills with gradients as steep as 36%. Turns with curve radii as low as 15 ft can be negotiated at full speed without skidding and while maintaining full control of the device.

Ergonomic evaluation by SHUMAC showed that the Segway is easy to use under normal conditions, even when surmounting obstacles, for a very broad range of users. Segways compare favourably with other types of vehicles, particularly in terms of stability, an area where they seem superior to other vehicles such as bicycles or mopeds. The ergonomic evaluation identified a certain number of weaknesses, including a marginally effective audible warning level, visual displays that were difficult to read in the sun, codes in shapes and colours that made interpretation of the information confusing, and an overly short shutdown time in case of breakdown. It also found, in one specific and probably rare case—i.e., shutoff of the power supply while the device was going up a steep gradient, that the device was impossible to immobilize and keep stable.

The evaluation also identified persons who should refrain from using Segways, particularly pregnant women, people with proprioceptive disorders,[6] and people with inadequate vision for driving any other vehicle, among others.

The results of the behavioural study, conducted on a target group of 49 people who had tested a Segway in a closed environment, indicated that the parameters to be taken into account in setting safe use standards were: training recognized by a government-certified organization, a minimum user age of 14, and the wearing of safety helmets. Obtaining a driver's licence was not deemed mandatory. Among the improvements needed to make this device safer were those concerning the audible alarm volume level, visual display, and shutdown time. The Segway was perceived to be a device designed to meet a large number of mobility requirements for a broad segment of the public. The survey results also indicated that Segways could possibly generate transfers to other forms of transportation, especially alternatives to automobiles.

1.2.2 Recommendations (Phase 1)

During Phase 1 of the project most users found the electric scooter and the EPAMD safe for travel in a closed environment: 75% for the electric scooter and 94% for the Segway. These data are of limited value since the testing was on a closed course.

[6] *Proprioception* is defined as "the ability to sense the position and location and orientation and movement of the body and its parts" (<wordnet.princeton.edu/perl/webwn>.

The authors recommended a second evaluation phase for Segways and electric scooters to be conducted under actual conditions of use and with a larger and more varied sample of users. This phase would in particular make it possible to evaluate the usage characteristics of the electric scooter and the EPAMD in various urban environments and climatic conditions : to document some of the views of these devices among sidewalk users; and to assess their potential intermodality applications and their economic viability as mobility tools.

1.2.3 Continuation of Evaluation, Phase 2

Following the tabling of the Phase 1 report, MTQ and SAAQ indicated they were in favour of conducting a second phase of evaluation, under certain conditions, of the Segway EPAMD alone. The authorities did not consider the electric scooter safe enough for testing on public roadways.

Phase 2 of the project was, therefore, concerned only with Segway HT EPAMDs. The study was conducted during the summer and autumn of 2005 on the kinds of pedestrian pathways for which the Segway was designed: sidewalks, bicycle paths and roadway shoulders with speed limits of 50 km/h or less.

The purpose of this second phase, carried out in accordance with the recommendations of the Phase 2 final report, was to observe:

- how these EPAMDs interacted with pedestrians in the various pedestrian areas, thus making it possible to assess the Segway's social acceptability;
- how safe the Segway is in urban areas;
- the effects of a dynamic environment – crossing intersections, various lighting conditions (day/night), various weather conditions (wind, rain, cold), etc. – on the use of Segway EPAMDs.

2. EVALUATION UNDER ACTUAL OPERATING CONDITIONS

2.1 STUDY OBJECTIVES

The project focused on three major objectives:

SAFETY AND ACCEPTABILITY

- To document EPAMD use in terms of safety
- To assess EPAMD use in pedestrian zones: sidewalks, roadside shoulders and bicycle paths
- To assess the perception of pedestrians, cyclists and motorists interacting with EPAMDs

STANDARDS OF USE

- To recommend standards of use for EPAMDs

ALTERNATIVE VEHICLE

- To document the value of a modal shift and opportunities for intermodal links
- To ascertain applications and target clientele

2.2 METHODOLOGY

The second phase of the project consisted of several stages which went from project development, working out agreements with cities, obtaining the devices, recruiting participants, conducting training sessions, etc., to drafting the final report. In addition to dealing with the necessary testing logistics, the project developed a data gathering approach.

To meet project objectives, a broad sample of users was needed over a long enough period to make sure users would acquire a certain familiarity with the device. Testing also had to be done in various urban environments (small and large cities) to ensure sufficient interaction with other roadway users, and under various weather and lighting conditions. The project obtained the co-operation of municipal and police authorities; in addition, given the project's experimental nature, roadway users were informed.

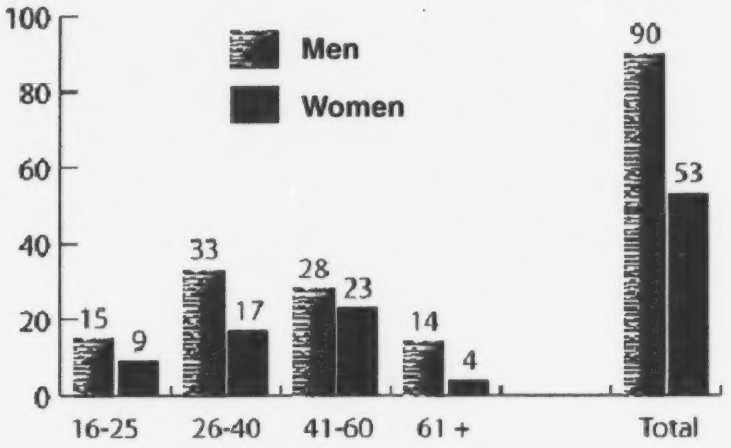
2.2.1 Selection of Participants

In all three test cities, participants were recruited in conjunction with the municipalities involved by means of advertisements, particularly in the various local media. Participant selection was based on a few criteria aimed at obtaining the most diverse and representative sample of the population possible. Participants were to be at least 16 years of age, in accordance with the manufacturer's recommendations; were to remain within the boundaries of the permitted traffic zones; and were required to have filled out a registration form. A selection was made in four age categories (16-25; 26-40; 41-60; 61+) and broken down by sex.

Furthermore, user selection criteria also had to reflect the various recommendations of the ergonomic evaluation regarding who should refrain from using an EPAMD, namely:

- pregnant women
- people with proprioceptive disorders
- people with shifted centres of gravity or carrying loads
- people with vestibular disorders
- certain elderly persons
- and people with inadequate vision for driving any vehicle

In all, 143 users (90 men and 53 women) were recruited and trained, then tested an EPAMD for one week in pedestrian zones, namely sidewalks, bicycle paths and roadside shoulders. In addition, in order to distribute the participants by age, four categories were created and used for participant selection.



Graph 1 – Breakdown of participants

The actual participant breakdown, that is, 37% women and 63% men, was slightly different from that originally planned, which called for equal distribution by age and sex. Although efforts were made to balance out age groups and sexes, a very large proportion of the registrants were men, probably because of a lack of interest among women.

Participants were invited to undertake training on about two days' notice, in order to ensure maximum participation. Participant recruitment was done among project partners (City of St. Jerome, City of Laval, Quebec City, SAAQ) and through a number of advertisements published in local newspapers or posted in buildings in the study areas.

In the three study areas, some 400 candidates were recruited, from whom 143 users were chosen.

2.2.2 Training

For this project, since participants had for the most part no experience with the Segway EPAMD, everyone took part in a training session recognized by the manufacturer; this served to make the testing as safe as possible and consistant with the experience of Phase 1. Participants were briefed on pedestrian safety rules and also on project-specific issues such as: authorized perimeter, special permission, pilot project, periods of interaction, helmet wear, etc.

1) Theoretical training

Users received about 90 minutes of theoretical training at the beginning of the session. This included a video presentation provided by Segway, a theoretical explanation of the operation of the device (performance, acceleration, braking, etc), the conditions for safe use of the Segway, instructions on driving ethics, and rules governing the project specifically.

2) Training documents

The user's manual (*Basic Rider Optimization Training for the Segway™ Human Transporter – Participant Workbook*), normally provided by the manufacturer (82 pages), and the SAAQ leaflet on legislation in effect governing pedestrian traffic[7] were provided to participants to ensure safe usage (8 pages in all).

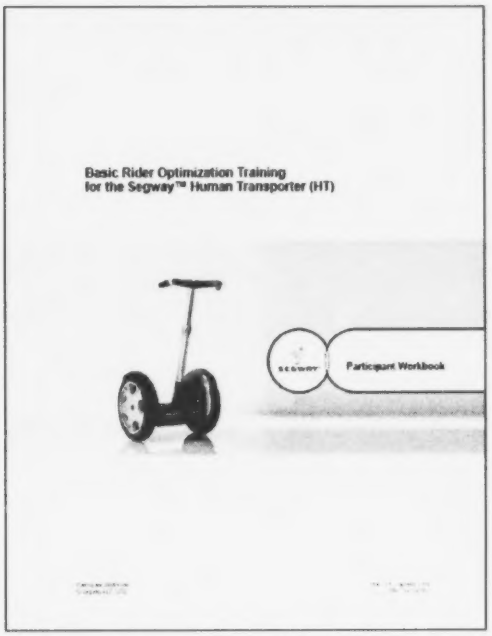


Figure 3 – Participant workbook (Segway HT)

Figure 4 – SAAQ leaflet on pedestrians

3) Practical training

The second phase of training, lasting more than 120 minutes, consisted of a practical workshop to acquaint future users with the operation of the EPAMD under various conditions. By means of practical exercises, users developed the right reactions when encountering obstacles, slopes and bumpy surfaces. The same artificial course used during Phase 1 of the project was also used for this practical segment. This specially designed wooden track is the same one the manufacturer uses for training. It simulates some everyday traffic conditions on sidewalks and various surfaces. It includes:

- A test corridor with plastic cubes in the middle
- A 20-degree slope ending in a stairway
- An environment consisting of:
  - a concrete, slab or cement surface
  - a steep ramp
  - a bumpy slope
  - various other obstacles represented by cones simulating entryways and doorframes.

[7] http://www.saaq.qc.ca/publications/prevention/pieton_conducteur.pdf

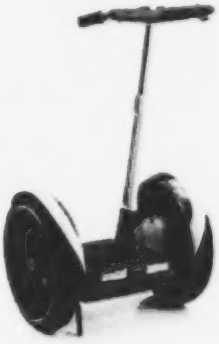
Figure 5 – Practical testing period

2.2.3 Devices Used

In all, 14 devices were available for the project, although only 12 were in use at any one time. The two extra devices were to substitute for those that had flats or other damage.

An agreement was reached with the manufacturer to borrow the devices for the duration of the project. In all, Segway LLC provided seven devices for the project. The rest were provided by the project partners, that is, the City of St. Jerome (3 devices); the City of Laval (3 devices); and the *Centre d'études professionnelles* in St. Jerome (1 device). In all, three different models were used by participants (p series, i series and e series).

Table 2 – Segway HT models used

			
p_series (2 units)	i_series (6 units)	i_180 (5 units)	e_series (1 unit)
Segway LLC x 2	Segway LLC x 5 St. Jerome x 1	St. Jerome x 1 Laval x 3 CEP St. Jerome x 1	St. Jerome x 1

The vehicles' range was the weakness identified by most users. In part, this may be because nine of the fourteen devices loaned for the project were used vehicles and their range had not been checked before testing began. Also, during the year, the manufacturer introduced a new lithium-ion (Li-ion) battery technology providing greater range.

2.2.4 Accessories

In addition to the devices themselves, certain accessories designed for the Segway and offered as options by the manufacturer, such as headlamps, front carrier bags and horns, were provided to participants. However, not all devices had lights and horns. As it turned out, the devices provided by the manufacturer lacked any accessories. The devices were also fitted with odometers to calculate the distance travelled.

Table 3 – Accessories used during the project

Front carrier bag

7 units

Horn

7 units

Keyed padlock

14 units

Headlamp
3.5 W rechargeable
7 units

Half of the devices had lights and horns. These accessories were intended to make the Segways more visible at night and to let users warn interactors they met or overtook. Explanations were provided to users who received accessories with their EPAMD so that they would use them correctly during their week's trial. However, where a front carrier bag was fitted to the middle of the handlebar, it muffled the horn so that it could barely be heard. And indeed, 53% of the users who had a horn fitted were dissatisfied with it.

2.2.5 Signage

To let others, mainly motorists, know they were entering an EPAMD test area, four signs were put up at strategic locations in each of the cities where the pilot project was being carried out. Additionally, identification signs were installed on the EPAMDs' handlebars.

Figure 6 – EPAMD identification sign

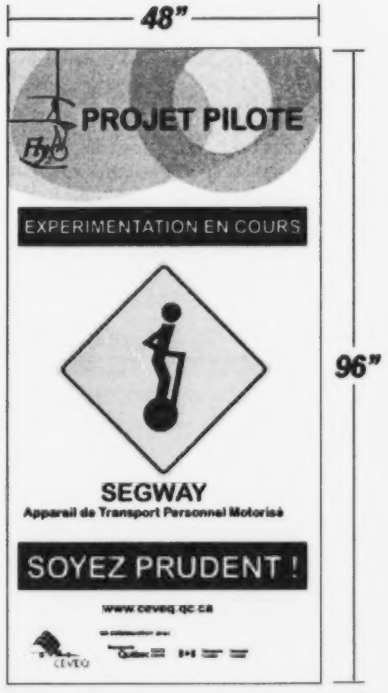


Figure 7 – Traffic signs (4 signs)

2.2.6 Data Gathering

Data gathering was done in three ways. To start with, at the end of each week of the test users completed a questionnaire giving their own perceptions of the device. In addition, they had to fill out incident reports if they had fallen or lost control of the device. Secondly, an interaction questionnaire was used to interview pedestrians, cyclists and motorists who came into contact with the EPAMD during interaction sessions. A third and final questionnaire was administered to the police in each participating city, to get a description of any incidents and/or complaints brought to the attention of the police.

Figure 8 – Participants in the first interaction session in Laval

The documentation used may be summarized as follows:

a) For users
   - Registration form
     - St. Jerome: 114 registrants
     - Laval: 186 registrants
     - Quebec City: 102 registrants
   - User questionnaire
     - 128 questionnaires returned out of 143 users
   - Incident report
     - 16 incident reports submitted by 11 users

b) For interactors
   - Interaction questionnaire
     - 360 questionnaires

c) For the authorities
   - Questionnaire for St. Jerome, Laval and Quebec City police forces
     - 3 reports

Figure 9 – Quebec City, interviewing a pedestrian

1) Users

To start with, a enrolment form was completed by candidates interested in participating in the project. This form was used to screen participants. Then, at the end of their week of testing, another questionnaire was administered to users, to elicit their experience with the EPAMD In their own words. Its purpose was to collect fairly qualitative data on the training taken, users' subjective experience and their opinion of the issues dealt with by this pilot project. That questionnaire will be found in Appendix 1. In addition, users had to complete a separate report on any incident/accident during their week's trial.

2) Interactors[8]

Short, guided interviews were done during the days or periods set aside for measuring EPAMDs' interaction with other users of pedestrian zones. During these periods, the concentration of EPAMDs was artificially increased to generate more interactions.

While these interaction measurements were being done, participants who had been loaned an EPAMD were asked to congregate at a predetermined place so as to increase the number of EPAMD users in the chosen perimeter. In all, thirteen periods of interaction were documented during the project. The interaction questionnaire had eleven questions, with yes or no answers. That questionnaire will be found in appendix 2.

3) Police forces

An official report was requested from the St. Jerome, Laval and Quebec City police departments. These various reports contain of information on the police perception of the EPAMD and a description of incidents that required police attendance, if any.

4) Odometers

In addition, to obtain a better quantitative view of the experiment, odometers were installed on the devices. Weekly readings were taken to determine how intensively the EPAMDs were used during the study.

[8] By "interactors" are meant all persons (pedestrians, cyclists, motorists) who use sidewalks, bicycle paths and road shoulders at speeds of 50 km/h or less in the study areas, other than Segway HT users, and who have agreed to fill out a questionnaire.

2.2.7 Study Areas and Administration

To achieve the project objectives, the study had to produce significant EPAMD traffic in various pedestrian zones. The project negotiated memoranda of understanding with the subject cities on EPAMD use in their territories, specifying the start date and duration of the testing.

Originally, the project was to be conducted in Montreal and St. Jerome for two consecutive six-week periods. However, negotiations with City of Montreal authorities dragged on, and the City of Laval showed an interest in participating. In the end, Montreal refused to participate in the study because police authorities in the borough of Plateau Mont-Royal were worried there would be complaints from pedestrians on the borough's sidewalks.

In view of Montreal's hesitation and the need to conduct the study in at least one large urban area, it was decided to do the testing in Laval and Quebec City, where the authorities were open to the project. Thus, the project began in St. Jerome on 11 July, though for a four- rather than six-week period. Subsequently, four weeks of testing per city was the rule for Laval and finally Quebec City.

1) ST. JEROME

St. Jerome, located in Montreal's northern suburban fringe, has nearly 61,000 inhabitants, distributed in four sectors (St. Jerome, St. Antoine, Bellefeuille, Lafontaine) covering more than 93 km^2. In most sectors, pedestrian density is low, as is automobile traffic in the areas authorized for the study: those with posted speed limits of 50 km/h or less. For study purposes, all of downtown St. Jerome, the *Petit train du nord* bicycle path and the St. Antoine sector were in the authorized perimeter.

2) LAVAL

With a population of nearly 365,000, the City of Laval occupies an area of 245 km^2 and is divided into six neighbourhoods. The City of Laval authorized Segway use in two of these. The first neighbourhood, St. Rose, has a downtown with large numbers of pedestrians, mainly in the Vieux-Sainte-Rose area. The second neighbourhood is Chomedey, farther south, with a lot of commerce and industry. Bicycle paths were also part of the testing network. Thus, it was easy for users to make the Route Verte part of their itinerary, as it cuts right through the study neighbourhoods.

3) QUEBEC CITY

Since the municipal mergers, Quebec City has had a population in excess of 508,000 and an area of 546 km^2. The neighbourhood chosen for the project was Old Quebec's Lower Town, in the heart of the borough of La Cité (Figure 12). Traffic in this area is relatively heavy compared to the other cities in the study (St. Jerome and Laval). The Lower Town area was identified by the authorities to avoid having Segway users attempting to climb the steep slopes between the Lower Town and Upper Town. The perimeter is defined by the Autoroute Laurentienne and the St. Charles River separating Quebec City from Limoilou. Once again, the purpose of restricting the area was to concentrate the units in one area and create a maximum of co-existence between EPAMDs and pedestrians.

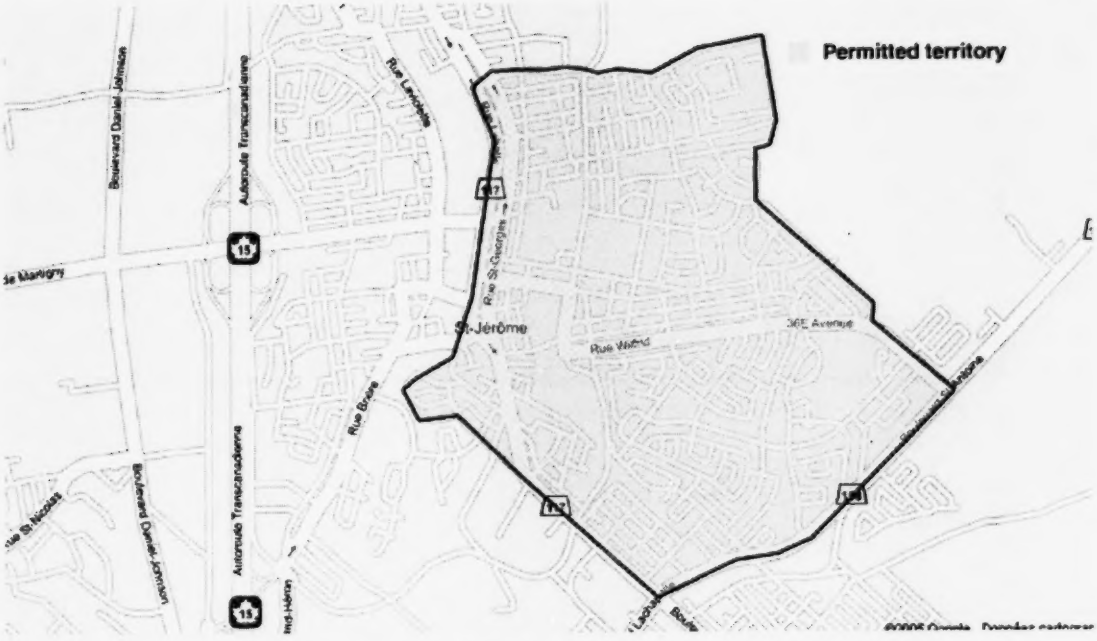


Figure 10 – Permitted territory in St. Jerome (maps.google.com)

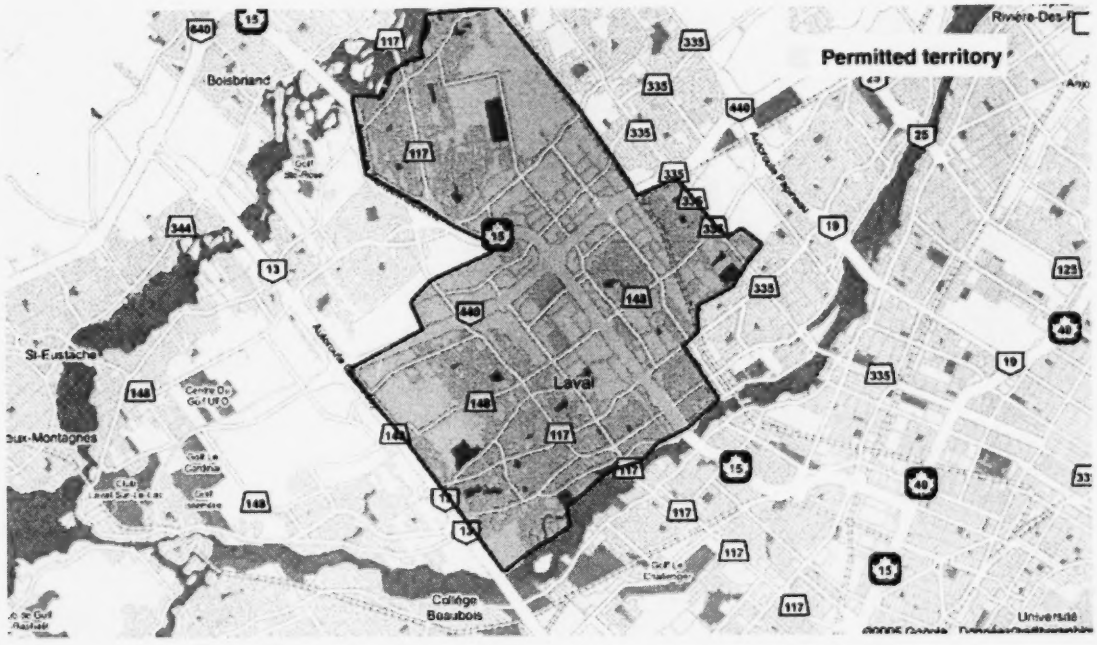


Figure 11 – Permitted territory in Laval (maps.google.com)

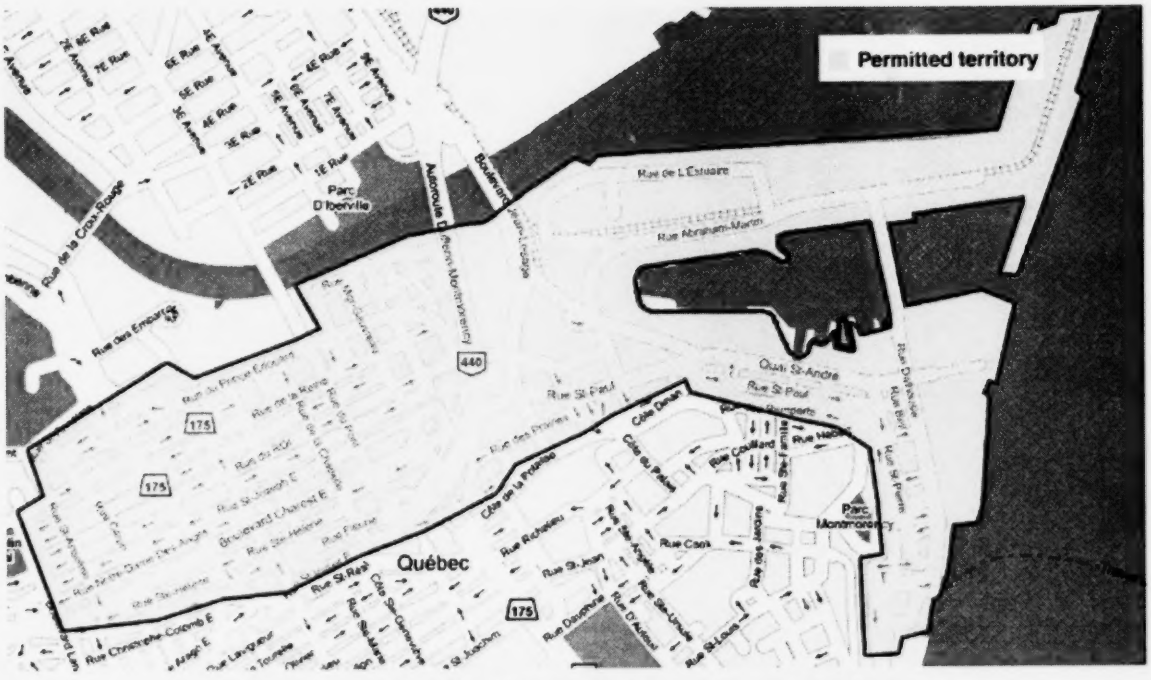


Figure 12 – Permitted territory in Quebec City (maps.google.com)

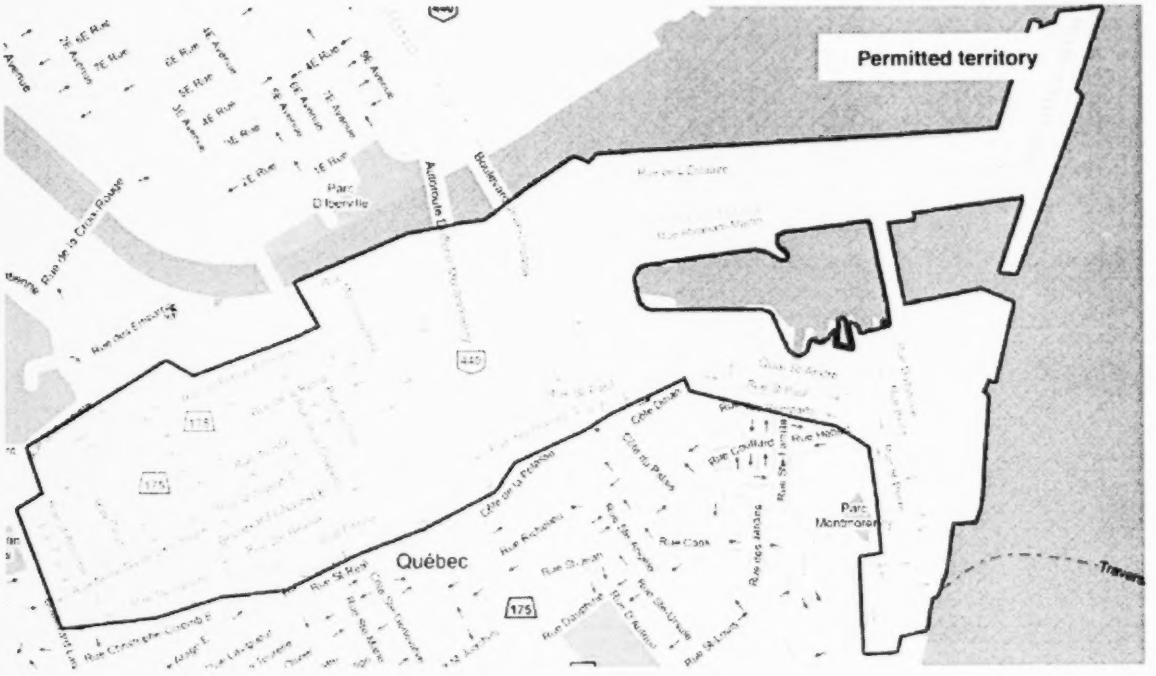
4) Usage zones within study territories

Three pedestrian zones were part of the evaluation project:

- sidewalks, the target zone, generally occupied by pedestrians. Many municipalities prohibit cyclists, inline skaters and skateboarders on sidewalks.

- bicycle paths, sometimes quite heavily travelled, already occupied by cyclists, skaters and boarders.

- shoulders – sometimes paved – of roads without sidewalks and with posted speed limits of 50 km/h or less. In this situation, the Segway is required to move like a pedestrian, that is, in the opposite direction to automobile traffic; this is different from the rule for bicycles.



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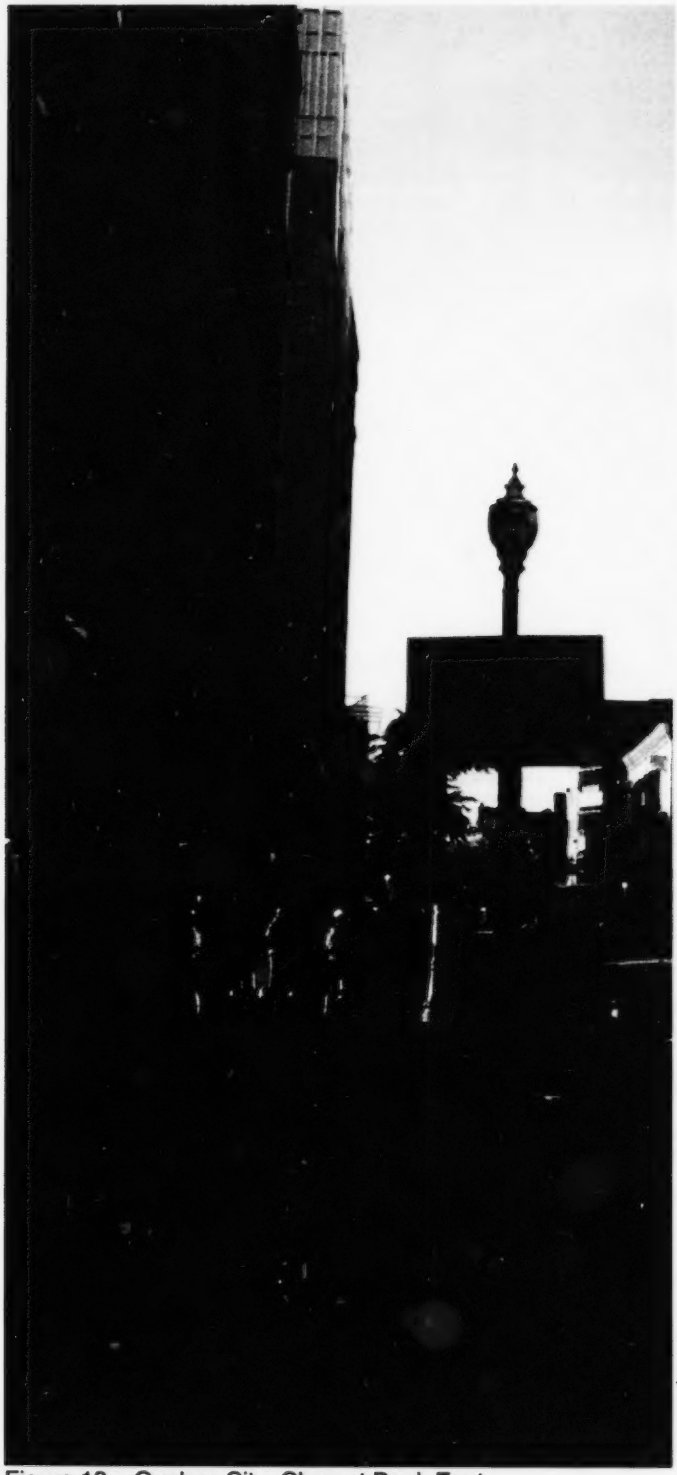


Figure 13 – Quebec City, Charest Boul. East

a) Sidewalks

Sidewalks are spaces normally reserved for pedestrians. They are normally found on either side of the street in urban centres, or on only one side in residential areas. Sometimes sidewalks are indoors, giving access to public buildings (metro and railway stations, etc). Roads and places less frequented by pedestrians may not have any sidewalks.

In the study cities, sidewalks were paved with concrete, stone slabs or concrete pavers. They have standard dimensions: four or five feet wide, with a height of six inches above the roadway. In general, sidewalks have a curb cut at intersections to allow mobility-impaired persons easy access. An intersection is the place where a road intersects with a sidewalk or bicycle path, accommodating pedestrian, bicycle and automobile traffic.

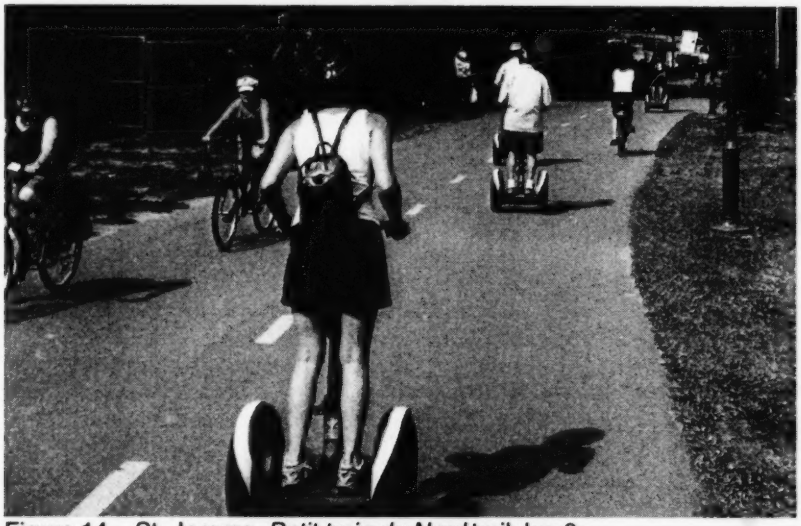


Figure 14 – St. Jerome, *Petit train du Nord* trail, km 0

b) Bicycle paths

Bicycle paths are specifically for bicycles but also accessible to inline skaters and pedestrians. They are free of interaction with motor vehicles.

Figure 15 – Laval, shoulder

c) Shoulders

Shoulders are areas alongside roads that do not have sidewalks. They are normally accessible to pedestrians, who walk facing traffic. Shoulders may be asphalt, gravel or dirt. Some roads may not have shoulders. In such cases, pedestrians, like EPAMD users, must use the edge of the paved roadway. For the purposes of this study, only the shoulders of roads with posted speed limits of 50 km/h or less were authorized.

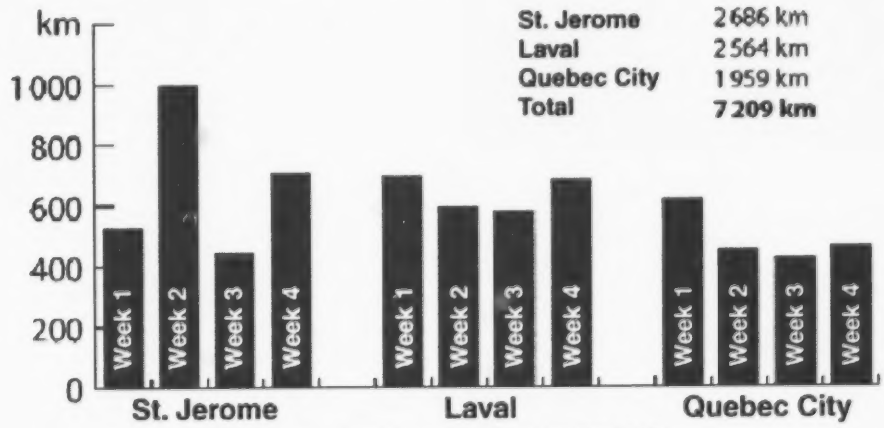
3. RESULTS

The results are presented in terms of the study objectives defined in section 2.1. They are mainly derived from the questionnaire responses and the interviews done with Segway users, interactors and police authorities in the three cities concerned. These data were analyzed by CEVEQ, which observed the conduct of the testing exercise, at least during training sessions and interaction. On occasion, CEVEQ shed some light on the data gathered. In addition, in discussing the results, some Phase 1 findings are invoked to challenge or support trends observed in Phase 2.

It is clear that the quality of questionnaire responses depends on the clarity of the questions. Also, to facilitate analysis, the answer choices for some questions limited respondents' freedom of expression; this may have distorted the results. Users did, however, have the chance to make free-form comments at the end of the questionnaire.

This chapter lists, for each category of study participants and each type of pedestrian zone defined, the main findings in terms of the acceptability and safety of the Segway HT and the standards of use to be proposed.

The distance covered by users, according to the odometers, is presented in Graph 2. It should be noted that the measured distances are at least 25% less than the actual because of odometer reliability problems. The total distance covered by the EPAMDs is estimated to be more than 9,000 km, or an average of more than 50 km per user. The odometer problems arose because of the difficulty in placing the magnets on the wheels and ensuring appropriate clearance between the sensor and the magnet, as the odometers were not designed for this application.



Graph 2 – Distances covered by EPAMDs

3.1 SAFETY AND ACCEPTABILITY

The EPAMD's safety and acceptability were the key issues in this testing. This section presents a number of considerations pertaining to the safety and acceptability of the Segway as seen by the rider, other road users and police authorities. A list of incidents/accidents is also presented and analyzed. All of these results are analyzed and discussed in section 3.4 to bring out aspects of safety and acceptability pertinent to the rider and other road users.

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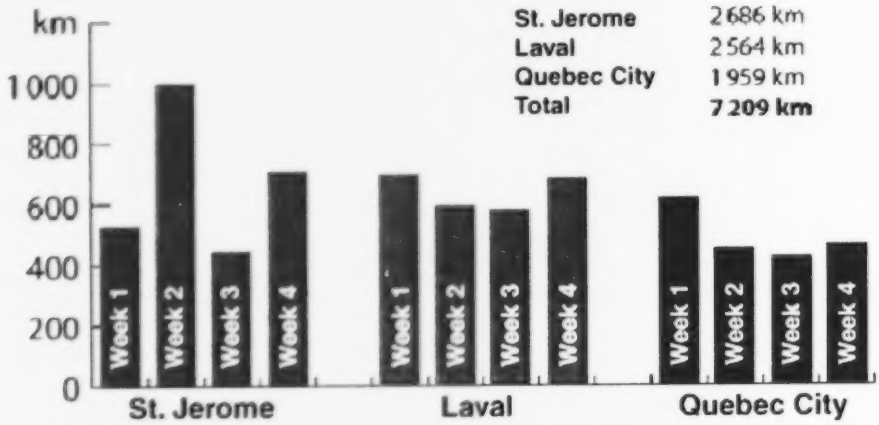

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3.1.1 Data Sources

To document the safety and acceptability testing, four types of document were compiled and analyzed, as follows:

- 128 user questionnaires
- 16 incident reports
- 3 reports by authorities
- 360 interviews with interactors

3.1.2 Safety and Acceptability As Seen by Users

The results of the compilation of 123 user questionnaires are presented here under a few major headings:

1) TRAINING

- 71% of users had heard only vaguely, or not at all, of the Segway.
- Close to half (43%) of users had some apprehensions before riding the device.
- 93% of users see training as an absolute necessity to ride an EPAMD safely.
- 92% of users consider the training received sufficient.
- In learning to ride the device, the following operations were described as having a high degree of complexity:
  - Getting around obstacles
  - Controlling the device on slopes
  - Handling the device
  - Driving reflexes

2) DRIVING TEST UNDER REAL-LIFE CONDITIONS

a) IN GENERAL

- 9% of users said they apprehensions at the end of the testing.
- 42% had the impression they were fully in control of the device.
- In interactions with pedestrians, the speed of the device (50%) and pedestrians' curiosity (40%) were the greatest risk factors.
- Getting on and off sidewalks and riding along them were, out of some twenty operations, the ones that most often produced a sense of insecurity.
- Cyclists' curiosity is the greatest risk factor (32%) in interactions with these users.
- Motorists' curiosity (42%) and visibility (32%) were the greatest risk factors in interactions with these users.
- Among some fifteen factors in the traffic environment (bumps, rain, wind, etc) that users found particularly troublesome, the worst were cracks in the sidewalk (25%) and potholes (25%).
- The great majority of trips were done during the day or evening, very seldom at night.

b) ON SIDEWALKS

- 60% of users responded that nothing had impaired their sense of security on sidewalks by day; this proportion was 66% in the evening.
- The operations deemed most difficult on sidewalks were:
  - getting onto a sidewalk with no curb cut (31%)
  - remaining on the sidewalk at all times (24%)
  - passing a pedestrian (17%)

c) ON BICYCLE PATHS

- 91% of users responded that nothing had impaired their sense of security on bicycle paths.
- Making one's presence known (horn, light, etc.) seems the most difficult thing on bicycle paths (16%).

d) ON SHOULDERS

- 86% of users responded that nothing had impaired their sense of security on shoulders.
- 4% of users consider the Segway's speed too high for shoulders.
- 5% said they had felt like a nuisance to other road users when the shoulder was congested; this fell to 3% when it was not congested.
- In the evening, 8% of users said they were affected by a lack of visibility.
- Being seen by motorists in the evening (making one's presence known) seems to be the most difficult thing for EPAMD users on shoulders (26%).
- Where there is no shoulder, users often tend to use the roadway.

3) ACCESSORIES

- 51% of users never used the light.
- 77% of those who did use it were satisfied.
- 73% of users never used the horn.
- 53% of those who did use it were satisfied.

4) PARTICIPANTS' COMMENTS

Here are a few representative comments by users:

"The device seems big enough never to go unnoticed. I liked the shoulders a lot more than the sidewalks, since the street provides much greater freedom to avoid all kinds of obstacle. Sense of security +++."

As the device is very new here, I had scads of questions from people who stopped me. They all said the same thing, though. Cool was the word used to describe the Segway, no matter what their age group! I didn't meet anyone who seemed hesitant about it. However, even though it's equipped with Michelin tires, you quickly find the ride leaves a lot to be desired on Quebec's roads and sidewalks. I had a bit soreness in the soles of my feet and my ankles and knees, as well as the occasional stitch during jaunts of more than an hour. Sometimes on the bicycle path and indoors, however. I really believe sidewalks are not at all suited to this type of device. Not wide or smooth enough. Too often you get things like garbage cans, recycling bins and trees on the sidewalks. That being said, this is still a marvellous device and very easy to use."
– Guy, age 32, St. Jerome

"For my age, a great experience."
– Florent, age 80, St. Jerome

"Sidewalks are not the thing at all. The speed is too fast, even with the black key. It bothers pedestrians. You often have to go onto the roadway. It's like joggers or cyclists on a sidewalk, people always to have move out of the way. It's ideal for bicycle paths. They're safe, generally in good condition, not too many big holes... . The cruising speed doesn't matter."
– Marie-Hélène, age 26, Laval

"Excellent training on obstacles, which was very important, as it taught us how to negotiate gravel and lawns as well as broken surfaces. The problem with sidewalks is the separation strips, which are jarring, and the up and down slopes at people's driveways, which are too common in residential areas without bicycle paths. Bicycle paths, in contrast, are easy to use, and cyclists do not seem to see the Segway as a obstacle, since like them we use only half of the path. My first suggestion is that they try to increase the battery range; it's nerve-racking to go more than a few kilometres, as you're always afraid of getting stuck. And there should be some easy way of determining how much farther we can go; it's unpleasant to have to trek back. Thanks for this opportunity!"
– Guy, age 55, Laval

"On sidewalks, pedestrians do not know that Segways are allowed there, they're not expecting an electric vehicle to come along, and they seem disinclined to share their space. Some bicycle paths are unpaved. For large-diameter, inline wheels like a bicycle's there's no problem, but for a vehicle with parallel wheels, it's dangerous. Several options seem to me to be essential: horn, light and kickstand when the rider leaves the Segway momentarily."
– Alain, age 48, Quebec

"On sidewalks, not a problem! If you ride smart, the Segway poses no threat. Thank you!"
– Carole, age 57, Quebec City

5) INCIDENTS DURING TESTING

During the Segway EPAMD evaluation project, it was planned that any incidents that might occur would be documented. In order to obtain as much information as possible on these events, incident report forms were issued to users, who were to complete them and turn them in when bringing back the Segway at the end of the week.

During the testing, 16 incident reports were filled out. However, it is important to note that several other minor incidents probably occurred, but were not reported. For instance, no reports were received from Quebec City, whereas participants said they had witnessed a few incidents. Though we were unable to track all incidents, Table 4 does present all those that were reported.

a) Conditions

- All incidents occurred during fair weather
- One incident report mentioned a wet surface

b) Injury

- 11 incidents caused minor injuries
- No incident required hospitalization
- All minor injuries involved bruises
- Three injuries involved minor cuts
- 5 incidents involving arm injuries were reported
- 7 incidents involving leg injuries were reported
- One incident report mentioned a head injury that was avoided because the rider was wearing a helmet.

c) Damage to the device[9]

- In 9 incidents, no damage to the device was reported
- 2 handlebars were seriously broken
- 3 platforms sustained damage
- One wheel had slight damage
- One flat was reported

d) Injury to others

- No injury to others was reported

e) Causes of incidents

- 6 incidents were brought about by riders' inexperience. Most of these occurred during the first days of the week's testing.
  - Turning too sharply
  - Sidewalk
  - Gutters
  - Poor reflexes – steering control
- 3 incidents were brought about by inattention
  - The rider didn't notice a rock on a sidewalk under construction
  - Failed to see a curve
  - Careless motorist
- 2 incidents were brought about by avoidance manoeuvres
- 2 incidents involved traction (lawns)
- One incident involved dismounting manoeuvres
- One incident involved the safety cutoff of power to the device after it had stopped (no more power)
- One slow leak was reported as an incident

f) Reports by police authorities

- No incidents involving a Segway were recorded by the St. Jerome, Laval or Quebec City police
- Quebec City police did, however, see participants riding beyond the set boundaries

[9] Several plastic mudguards were repaired or replaced. Broken or defective odometers were repaired or changed every week. One device could not be repaired.

Table 4 – List of incidents recorded during the study

When	Experience	Place	Cause	Nature of damage
July 11 8 p.m.	0 day	Sidewalk	Inexperience, power cut	Equipment: odometer fell off
July 12	1 day	Park – pedestrian space	Practising manoeuvres on the grass, no traction	Nil
July 13 9:45 p.m.	2 days	Sidewalk	Inexperience, speed too high approaching the sidewalk	Minor cuts and bruises Equipment: handlebar broken
July 19 2 p.m.	1 day	Shoulder	Inexperience, poor steering reflexes	Superficial bruises to left elbow
19 July 19 8 p.m.	1 day	Sidewalk	Inexperience, going down a hill	Minor scratches (hands, elbow, hip) Equipment: handlebar broken
July 21 10:30 p.m.	2 days	Bicycle path	Poor visibility, inattention	superficial bruises to elbow
July 25 12:45 p.m.	0 day	N/A	Inexperience in dismounting from the device	Superficial bruises to head and shin, scare
July 26 7:30 a.m.	1 day	N/A	Inexperience in dismounting from the device	Superficial bruises to the shin
July 26 2 p.m.	1 day	Sidewalk	Inexperience, poor steering reflexes	Minor bruises to back, elbow and knees
July 26 7:15 p.m.	1 day	Private residence	Inexperience, trying to ride on grass and cross a concrete border	None, no fall
July 28 5 p.m.	3 days	Shoulder	A motorist, distracted by the EPAMD, caused the rider to make a false move	Superficial cuts and bruises to legs and hands
July 29 11 a.m.	4 days	N/A	Flat	Equipment: flat
August 2 9 a.m.	1 day	Sidewalk	Inexperience, loss of control, wheel dropped off the sidewalk	Superficial bruises to right leg
August 2 10 a.m.	1 day	Parking lot (public market)	Inexperience, poor steering reflexes, set foot on the ground while vehicle was moving	Superficial bruises to the foot
September 4 3 p.m.	3 days	Shoulder	Distraction, loss of control in the course of an avoidance manœuvre	Bruises to pelvis and hip
September 9 12:45 p.m.	4 days	Sidewalk	Distraction and poor driving position, hitting a rock	Minor bruise on right shoulder

6) CEVEQ TEAM'S OBSERVATIONS

Even though the project was supervised and regulated, it appears some riders went outside the test areas and did not fully comply with instructions for use of the device. It was reported that some participants allowed a number of people to ride the Segway, despite being warned not to. The Highway Code as it relates to pedestrians was not always observed either. These delinquent behaviours show that even when users can make their trips more quickly, they are not necessarily any more patient at intersections and don't always wait for the traffic light before crossing an intersection, for example. With respect to pedestrian zones, EPAMDs frequently took to the shoulder even where there was a sidewalk. How to explain this? Maybe it's the fact that some sidewalks are narrow or bumpy, or perhaps when there are a certain number of pedestrians Segway users felt intrusive. Finally, a few of the incidents reported were the result of riders' overboldness.

However, it is important to remember that, despite the misbehaviour of some participants, not one pedestrian, cyclist or other pedestrian route user suffered any injury on account of an EPAMD. Nor was there a single complaint filed with the police in the cities where the project was carried out.

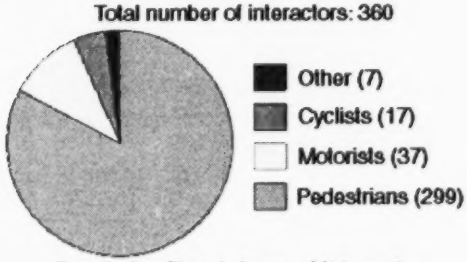
3.1.3 Safety and Acceptability As Seen by Interactors

During their week of testing, participants were to take part in interaction meetings to document the reactions of motorists, pedestrians and other road users to the Segway. A massive concentration of Segways (all available participants, i.e. 6 to 10 Segways) was created each week on sidewalks, cycle paths and road intersections, often at peak traffic hours. During these sessions, the study organizers sought the impressions of other road users through a survey.

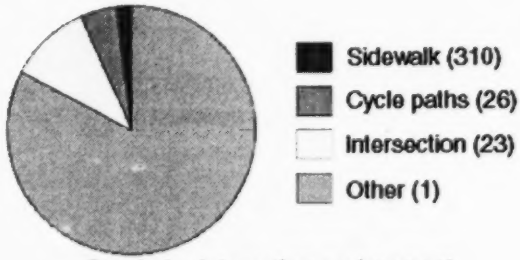
In all, thirteen interaction sessions were conducted: four in St. Jerome, four in Laval and five in Quebec City. However, after the first interaction session, the organizers realized that the questionnaire was too long and changed it at once. Therefore, the results of the first interaction session, in St. Jerome, were discarded; the results in this report are based on a total of twelve interaction sessions: three in St. Jerome, four in Laval and five in Quebec City.

1) INTERACTORS

During the twelve interaction periods, 360 persons responded to the interaction questionnaire: 89 from St. Jerome, 61 from Laval and 210 from Quebec City. The respondents fell into six categories: pedestrians, motorists, cyclists, skaters, mobility-impaired persons using wheelchairs, and skateboarders. The very great majority of respondents consisted of pedestrians, encountered mainly on sidewalks.



Graph 3 – Breakdown of interactors



Graph 4 – Interaction environment

Of thirteen documented interaction sessions during the project, ten were held in the afternoon and three in the evening. The density of pedestrians and other users was always low in St. Jerome and Laval.

As it seems there is no common reference in the literature to define a level of sidewalk use, the authors decided to use the values described in Table 5, which are based on the *Highway Capacity Manual (HCM)*,[10] to characterize the pedestrian density present in the areas visited for the interaction analysis periods.

The level of sidewalk use in Laval and St. Jerome may be estimated at between A and B, that is, about 4 m^2 per pedestrian. In the case of Quebec City, with certain areas having a higher pedestrian density and taking into account the times when the interaction periods took place, the level of use might reach level C, even D, especially close to intersections. In these cases, we reckoned one pedestrian to every 1.4 m^2.

Table 5 – Pedestrian density (Level of use)

Level of Use *(LOU)*	Space (m^2/pedestrian)	Flow (pedestrians/min/m)
A	> 12	< 7
B	3.7-12	7-23
C	2.2-3.7	23-33
D	1.4-2.2	33-49
E	0.6-1.4	49-82
F	< 0.6	> 82

2) PEDESTRIANS

- 299 pedestrians were questioned, including 290 on sidewalks
- 6.3% of pedestrians said the EPAMDs had got in their way
- 12% said they had changed course because of an EPAMD
- Fewer than 1% said they had been placed in a hazardous situation by EPAMD users
- 13% of interactors thought an EPAMD was more dangerous than a pedestrian at intersections
- 38% of interactors thought an EPAMD was more dangerous than a pedestrian on sidewalks
- 12.6% thought the EPAMDs went too fast
- 40% of pedestrians thought the sidewalk was no place for an EPAMD
- 9% do not favour EPAMD use on bicycle paths
- 70% of pedestrians favour EPAMD use on shoulders

a) Comments

Here are a few representative comments by pedestrians

They should follow the bicycle code. (St. Jerome)
Good idea! Danger = user. (St. Jerome)
Because the sidewalks are not wide enough, they're in the way. (St. Jerome)
Seems safe, not fast, not wide, cute! (Laval)
Looks like great fun, for short trips = great! (Laval)
Maybe if the sidewalk is wide enough, a good means of transportation. (Laval)
Segway traffic on sidewalks? Depends on the speed. (Quebec City)
Depends on the rider. (Quebec City)
Should go on the street rather than the sidewalks. (Quebec City)

[10] Highway Capacity Manual (HCM), Chapter 13.

3) MOTORISTS

- 36 motorists were questioned at intersections
- No motorists said an EPAMD had got in their way
- 14% thought an EPAMD was more dangerous than a pedestrian at intersections
- 19% thought an EPAMD was more dangerous than a pedestrian on shoulders

a) Comments

Here are a few representative comments by motorists:

They're like wheelchairs. (St. Jerome)
No more dangerous than a bicycle. (St. Jerome)

4) OTHER USERS

This group includes 17 cyclists who encountered an EPAMD on a bicycle path or the shoulder and 7 other pedestrian zone users: four skaters, two skateboarders and a person in a motorized wheelchair. As there were so few, they were added to the other users category.

- No cyclists said they had been bothered, had found the EPAMDs went too fast, or had had to change direction because of a Segway
- 17% of cyclists thought an EPAMD was more dangerous than a pedestrian on shoulders
- 59% favoured their use on sidewalks
- 88% favoured their use on bicycle paths
- 70.5% favoured their use on shoulders

a) Comments

Here are a few representative comments by cyclists:

It all depends on the rider, just like a bicycle. (St. Jerome)
Fun, practical, not on bicycle paths. (St. Jerome)
Let them be, but watch for children. (St. Jerome)
On the shoulders, not the sidewalks. (Laval)

3.1.4 Safety and Acceptability As Seen by Police

1) SIDEWALKS

- As the authorities did not report any incidents or complaints, they were not opposed to EPAMD use on sidewalks.
- However, police authorities did say the sidewalk is certainly the most sensitive area for the use of these devices. They emphasized the need for rider training and public information.

2) SHOULDERS

- The authorities made no remarks about safety on shoulders. However, City of Laval authorities were interested in knowing if users would behave in the same way in getting around parked cars when they were pedestrians. The study showed that 7 times out of 10, users would have behaved the same way had they been on foot.

3) BICYCLE PATHS

- No reported incidents and no complaints
- Public education, both for the general public and for riders, is vital.

3.2 STANDARDS OF USE

One of the study objectives was to propose some standards for EPAMD use. Below are some statistics based on the responses received from participants and interactors. Police authorities were not asked to comment on this.

3.2.1 Training

- 95% of participants who received the 3-hour training felt ready to ride.
- 65% of participants felt that recognized training should be among the things governed by a regulatory framework.

3.2.2 Helmet Wear

- 71% of participants thought a protective helmet should be a regulatory requirement for riding a Segway EPAMD.

3.2.3 Speed

- 53% of participants were against the imposition of a speed limit for use on sidewalks.
- Among the 47% who did favour such a limit:
    - 59% said it should be 10 km/h,
    - 24% said 15 km/h, and
    - 12% said 20 km/h.[11]

3.2.4 Time of Use

- 81% of participants thought EPAMD use should be prohibited at night.

3.2.5 Age Limit

- 86% of participants thought riders' age should be regulated. 65% of them thought the minimum age to ride a Segway EPAMD should be 16. It should be noted that of five parameters that could be regulated, minimum age is seen as the most important.

3.2.6 Usage Zones

1) Sidewalks

- 50% of participants would be interested in using the devices on sidewalks.
- 38% of pedestrians interviewed on sidewalks thought that the Segway EPAMD posed more of a danger than a pedestrian.
- 13% of pedestrians interviewed on sidewalks said they found these devices went too fast.
- 40% of pedestrians think the EPAMD has no place on sidewalks.

[11] Under ideal conditions the Segway's maximum speed is 20 km/h.

2) Bicycle paths

- 72% of participants would be interested in using the devices on bicycle paths.
- No interactors interviewed on the bicycle path reported that the Segway EPAMD had got in their way.
- Most cyclists interviewed thought EPAMDs on bicycle paths were fine.
- 86% of pedestrians interviewed on a bicycle path thought EPAMDs on bicycle paths were fine.
- 8% of interactors interviewed on a bicycle path thought the EPAMDs went too fast.

3) Shoulders

- 86% of participants said nothing had impaired their sense of security on shoulders.
- 71% of interactors thought Segways on shoulders were fine.

3.3 THE EPAMD AS AN ALTERNATIVE VEHICLE

"Intermodality" means using several means of transport during a single trip. It aims at reducing the use of private cars and the in concomitant harmful effects by promoting the combined use of various less polluting modes such as public transit, walking, car-pooling, bicycles, inline skates, car-sharing. For intermodality to develop, good alternatives to the private car must first be offered.

In Phase 1, the results of the survey of 49 closed-course Segway users showed that the device could potentially bring about a modal shift. Indeed, the data collected in 2003 showed that if people had Segways, they would use them more for their short trips (less than 3 km). These trips would mainly be shifted from cars. At the time, 33 people indicated that they regularly used their cars for short trips. Only 9 would still do so if a Segway were available.

Walking was also somewhat affected by a mobility shift. Six trips would be done by Segway rather than on foot. The data suggest that this shift is mainly among the elderly and people with weight problems (more than 90 kg).

The mobility shift seems marginal with respect to cycling and public transit use. The Segway does not seem to have an impact on these two modes of transportation.

3.3.1 Complementarity of the Segway with Other Means of Transportation

In Phase 2, 123 users were surveyed using a limited number of questions to get their opinions about the alternative vehicle/intermodality issue. The results are as follows:

- 81% consider the Segway complementary to other means of transportation, 19% do not.
- For 53% of users, it is complementary to the bicycle,
- 51% find it complementary to walking, whereas 19% and 16%, respectively, find it complementary to the train or taxi.

3.3.2 Applications and Target Clientele

- 72% of the users questioned would be interested in riding a Segway on bicycle paths and 50% on sidewalks.
- 74% would be interested in using it inside an industrial or private space and 80% inside a shopping centre.
- 83% of the users find the Segway suited to industrial uses, 75% to personal use and 49% to police work.

- 55% would be interested in buying a Segway EPAMD.
- 80% said they would be willing to pay less than $2,000 for the device, whereas only 4% would buy it at a price of between $3,500 and $4,000.

In daily applications,

- 65% of users find the Segway useful for neighbourhood jaunts,
- 55% for commuting to work, whereas 10% find it suited to neither activity.

3.4 DISCUSSION OF RESULTS

3.4.1 EPAMD User Safety and Perceived Nuisance Factor

The Segway user's safety is to a great extent dependent on the device itself, the user's mental and physical capacity and maturity, the training received, and the physical setting in which the device is used. However, it is important to distinguish the safety results from those concerned with the device's acceptability or the perceived nuisance factor. For users, safety is the predominant factor.

1) Safety

This issue was approached from the following points of view:

a) Training

In Phase 1, a certain number of parameters were studied, including the device's performance, its ergonomic qualities, user training and the response to this training, by surveying a sample of 49 users from 16 to 80 years old. The great majority (94%) found the 4 hours of training altogether appropriate. Moreover, ergonomic analysis established that learning to ride a Segway is about as complex as learning to ride a bicycle, or less so. There is only a small percentage of the population that seems unable to use a Segway for various reasons (see section 2.2.1).

The purpose of Phase 2 was, among other things, to do additional safety testing of the Segway in a dynamic urban environment. Thus, a larger sample of users (143) was selected and trained using a protocol very similar to the one used in Phase 1. Additional instructions specific to the requirements of the testing under real-life conditions and rules on pedestrian behaviour were added. Users quickly gained control of the Segway, to the point where the great majority (more than 90%) indicated that they felt ready to ride normally following the training. For the great majority, this training was adequate and absolutely necessary.

Following Phases 1 and 2, CEVEQ concluded that the training prescribed by the manufacturer, when given by a qualified person, provides users with the necessary initiation to ensure their safety and that of other road users. Moreover, the manufacturer obliges its distributors to give a minimum of 30 minutes' training upon purchase of the device and urges the customer to take the complete training, which is offered by the distributor for a fee. Lastly, if customers do not want to take the training, they must complete a release form stating that they declined the recommended training.

b) Minimum driving age

It is clear that users' age and maturity can affect safety, both their own and that of other users of pedestrian zones. The Segway manufacturer recommends a minimum age of 16. In Phase 1, after a few hours of familiarization with the device, users suggested a minimum age of 14. In Phase 2, after training and one week's riding experience, nearly 50% of the 123 users favoured a minimum age of 16 instead, while 20% thought 18 would be better. An examination of regulations in effect in the United States reveals that only 50% of the states where the Segway is authorized set a minimum age. Where an age is set,

16 is usual. Phase 1 testing did not explore this issue, as the selected candidates were all 16 or older, as recommended by the manufacturer. It thus appears advisable to set the minimum age at 16.

c) Driving experience

After a week of driving experience, 9% of users still had certain apprehensions about Segway use. An analysis of the incidents shows that most occurred in the first days of the week of testing. It is safe to assume that user safety improves with driving experience. According to the manufacturer's documentation, Segway training goes through four phases:

1. Unawareness, incompetence: Users don't know what they don't know.
2. Awareness, incompetence: They know there's a lot they don't know.
3. Awareness, competence: They are competent, but must focus on the manoeuvres.
4. Unawareness, competence: They have acquired automatic reactions and no longer have to think to control the device.

It is important to note that during the project, few users reached the fourth phase of learning since they had the devices only for a week. Most of them developed some driving skill, but not yet sufficient experience to acquire some of the automatic reactions that come from long-term use of the device.

d) Use on sidewalks

Riding on sidewalks gave users a certain sense of insecurity. Getting onto a sidewalk with no curb cut, remaining on the sidewalk at all times, and overtaking a pedestrian were among the operations considered most difficult by users. There are several reasons for this. Where there is no curb cut, users must change usage modes (to assistance mode) to mount the curb, which slows them down. Overtaking a pedestrian is especially difficult when the sidewalk is narrow. And lastly, keeping on the sidewalk can be difficult for users because of its uneven surface and the many obstacles found there. It was reported—and witnessed by the project team—that users having difficulty riding on the sidewalk because of pedestrian congestion or an uneven surface would veer off onto the roadway alongside. Lastly, when the sidewalk was free of pedestrians, speed became the factor that caused the user the most insecurity. It should be understood here that users have total control of their speed, and so of their safety.

It should be noted as well that after using their Segway for one week, only 50% of the 128 users who turned in their questionnaires said they would be interested in using the device on sidewalks. They said they automatically slowed down when pedestrians were present, because they came to feel they were a nuisance to pedestrians on sidewalks.

e) Other factors affecting user safety

Interactors' curiosity about the EPAMD seems to be an insecurity factor for the user, whether on sidewalks, bicycle paths or at intersections. This is probably related to the novelty of the Segway on pedestrian routes. In the future, if Segway use is authorized and these devices become popular, this insecurity factor will gradually diminish. If the decision is made to authorize their use, it will be important to mount a publicity campaign to let the public know how they should behave toward this new road user.

Little testing was done and no interaction sessions were held in the evening or at night, but some users said they were not very visible to cyclists and motorists at these times. However, three-quarters of the users who made use of the accessory headlights offered by the manufacturer were satisfied with them.

Segways were used in the rain by slightly less than half of the users, the great majority of whom said they had felt safe under these conditions.

2) The nuisance or acceptability aspect

The only place in pedestrian areas where users felt they were a nuisance was on sidewalks, and particularly when they met a pedestrian. Riders said they automatically slowed down when pedestrians were present, because they came to feel they were a nuisance to pedestrians on the sidewalks.

3.4.2 Safety and Acceptability As Seen by Other Road Users

In the light of these results, it appears important to distinguish between pedestrians' perception of safety and the Segway's acceptability on sidewalks and in other pedestrian areas. The primary issue here is the nuisance factor; safety is a secondary consideration. We shall look at the nuisance factor in terms of the following traffic zones:

1) Use on sidewalks

With regard to pedestrian safety, in the 9,000 km covered by neophyte users, not one incident involving a pedestrian or interactor was reported. Only 1% of the pedestrians surveyed said they had been placed in a dangerous situation by an EPAMD user. It should be recalled that all interviews with pedestrians were conducted during interaction sessions involving between 6 and 10 devices operating within a restricted perimeter at rush hour, artificially increasing the number of interactions. This, therefore, represents a worst case scenario. Under normal Segway and pedestrian density conditions, the perception of insecurity and nuisance could be less. Traffic speed is another parameter that may affect pedestrian safety. However, only 12% of pedestrians found the Segways went too fast.[12]

With respect to acceptability, two pedestrians out of five (40%) who met a Segway on the sidewalk felt it had no business being there. When meeting an EPAMD, 12% said they had had to change course and 6.3% said that the EPAMD had got in their way. In addition, 38% found a Segway rider more intimidating than another pedestrian.

The testing in this pilot project, and particularly the interaction periods, show that the presence of Segways on sidewalks poses very little threat to pedestrians' safety and integrity. As regards the acceptability of their presence on sidewalks, that is less clear. This concern over the perceived nuisance factor seems to support the apprehensions of the Plateau Mont-Royal police in Montreal, where the sidewalks are usually very crowded and pedestrians are already complaining of sidewalk nuisances (see section 2.2.8).

2) Use on bicycle paths

During 27 interactions on bicycle paths, the majority being with cyclists, 88% of interactors said they were in favour of EPAMD traffic on bicycle paths. No one was bothered by their presence. It seems, therefore, that in this traffic zone there are no safety or acceptability issues.

3) Use on shoulders

About 15% of the cyclists and motorists interviewed considered an EPAMD on the shoulder of a road with no sidewalk more intimidating, safety-wise, than a pedestrian. None of them said they had been disturbed or made to change course by a Segway; 70% favoured their use on shoulders. It seems, therefore, that in this traffic zone there are no safety or acceptability issues. It should be noted that during testing, users were told to ride on the shoulders facing automobile traffic, as stipulated for pedestrians in the Highway Safety Code.

[12] The CEVEQ team notes: Pedestrians often asked the pollsters about the EPAMDs' speed. When they were told they could reach 20 km/h, many said that was too fast. When they got no answer but had to rely on their own experience, very few thought the EPAMDs' speed was excessive. It is difficult to determine how many respondents were quoted a top speed for the Segway.

4) Motorists' viewpoint

According to the 36 motorists interviewed, EPAMDs encountered at intersections and on shoulders were not in their way. About 15% thought they posed a greater danger than a pedestrian. As already mentioned, the presence of Segways in great numbers at the interaction sessions aroused motorists' curiosity. However, motorists' curiosity about EPAMDs may be expected to tail off as they become a commoner feature in the urban landscape.

5) Police viewpoint

Although police authorities believe that Segways may pose a danger to other users of pedestrian routes, they consider public education paramount. Nonetheless, they also consider that Segways could be used for patrolling. Since 2002 in the United States, more and more police departments (Atlanta, Georgia; Boston, Massachusetts; Santa Monica, California; Fond du Lac, Wisconsin; etc.) have been acquiring Segway EPAMDs to patrol pedestrian zones and airports.

3.4.3 Safety and Acceptability Summary

In the light of this evaluation—involving 143 users who, after 3.5 hours of training and a week of Segway use, covered more than 9,000 km on sidewalks, bicycle paths and shoulders in urban environments—the following are the major findings on the safety and acceptability issues:

- No incident or serious accident was reported, so concerns for the safety aspect were lessened;
- Following a guided 3.5-hour training session, Segway users were easily able to use the device on public roadways;
- EPAMD traffic on sidewalks generates feelings of insecurity among users and pedestrians alike;
- The feeling of insecurity expressed by users generally arises from their lack of confidence about being able to properly control the device under difficult conditions, as when encountering a pedestrian or navigating tight spaces and difficult surfaces, conditions often existing on sidewalks. Most likely, with more driving experience, users' confidence will improve, as is the case with learning to ride a bicycle;
- Among interactors, and in particular pedestrians on sidewalks, perceptions are a blend of safety concerns and the nuisance factor. The latter seems a greater concern than safety, since no incident or serious injury was reported in the course of 9,000 km of testing by users with little driving experience. The perception of nuisance is most probably exacerbated by the exceptionally large number of Segways and pedestrians that were interacting. Under normal conditions of use, the nuisance factor should significantly diminish;
- EPAMD traffic on bicycle paths and road shoulders does not seem to cause any nuisance or safety problem.

Training/initiation in Segway use by the manufacturer, as well as the user's age/maturity and helmet wear, are expected to contribute to safer use of the Segway EPAMD.

In order to control or minimize the nuisance factor on sidewalks, it is possible to prohibit Segway traffic at peak traffic hours or in certain urban areas that are not well suited to it. Moreover, in order to help municipalities provide for safe EPAMD traffic while minimizing any nuisance, a guide to safe traffic conditions could be prepared.

3.4.4 Standards of Use

Based on the evaluation of testing phases 1 and 2, the following usage parameters appear most important in providing for the safety of riders and other raod users, while at the same time making Segway EPAMD use more harmonious and acceptable.

1) Minimum driving age

This was the parameter deemed most important by users in Phase 2. It was thought that 16 should be the minimum age required. In accordance with the manufacturer's recommendations, users chosen for testing in Phases 1 and 2 had to be 16 or older. In Phase 1, after a few hours' familiarization with the Segway, users suggested a minimum user age of 14. Nearly 50% of the user group in Phase 2 favoured a minimum age of 16 instead, while 20% thought it should be 18.

An examination of the regulations in effect in the United States (see Table 1) shows that most states have opted for a minimum age of 16, if any. Nearly half of the states have no minimum age. That being so, it seems advisable, for the moment, to follow the manufacturer's recommendations and set a minimum age of 16; especially if there is no formal training or driving test required for riding this EPAMD.

2) Wearing a protective helmet

This is the second parameter to be looked at in order of importance, according to users in Phase 2. More than 70% believe that a bicycle-style protective helmet must be required for user safety. As the EPAMD can reach speeds of 20 km/h and riding surfaces are often rough, loss of balance and falls are possible, so it is very appropriate to require such protection to be worn.

3) Training

Training such as was provided during the project should be strongly recommended to EPAMD users. Since Segway operation is perceived to be no more complex than riding a bicycle, and the manufacturer does provide at least 30 minutes of training to its customers, there is no justification for requiring EPAMD training.

4) Time of use

Nighttime use of EPAMDs should be subject to the same requirements as for bicycles. At minimum, a headlight should be used when riding at night. The Segway already has reflective strips around the platform and the wheels as standard equipment.

5) Usage zones

Segway use on the shoulders of roads posted at 50 km/h, bicycle paths and sidewalks does not compromise either users' safety or that of persons coming into contact with the device in pedestrian areas. User education during training and public awareness campaigns could greatly facilitate acceptance of EPAMDs on sidewalks.

3.4.5 The Segway As a Substitute for the Automobile

Though the study did not focus on the modal shift the EPAMD could represent, some brief replies taken from the results of Phase 2 suggest that half of the users would be interested in buying a Segway. True, few users (4%) were ready to buy one at the current price of between $3,500 and $5,000. The majority of the participants (61%) see the Segway as a new personal transport device for trips in the urban environment, though only 50% think they would use it on sidewalks. In Phase 1, nearly half of the

participants in the study said they would be ready to shift from the automobile to the Segway for trips under 3 km.

Given its zero emissions, its electrical propulsion—an energy source that is practically 100% renewable in Quebec—the authorities must take a positive view of this new means of urban mobility. The Segway is an attractive alternative for short trips within the city. As part of a policy of sustainable development, the Segway EPAMD should be permitted to operate under the necessary supervision to ensure the safety of road users and minimize any disturbances.

However, given the Segway's current price and the regulations in effect in Quebec and in Canada that prohibit its use on public roads, it is difficult to foresee its wide adoption.

4. CONCLUSIONS

Evaluation of the Segway EPAMD was carried out in two phases. The first was conducted in a closed-circuit environment, with 49 users, for purposes of technical and ergonomic evaluation. The second phase consisted of testing under actual operating conditions on public roadways and involved 143 users, who covered more than 9,000 km in three cities.

The following conclusions were arrived at with regard to the project objectives:

4.1 SAFETY

a) During Phase 1, technical testing results showed that under normal operating conditions the Segway HT is stable, operates smoothly and gives the user a feeling of control.

b) Ergonomic evaluation showed that the Segway is easy to use in normal conditions, even when surmounting obstacles, for a very broad range of users. The device compares favourably to other types of vehicle, particularly with respect to stability and ease of learning, where it proved superior to other vehicles such as bicycles or mopeds.

c) The 3.5-hour training period provided and strongly recommended by the manufacturer, does offer the necessary initiation for the safe operation of the Segway on public roadways.

d) Training/initiation in Segway use, the user's age/maturity, and helmet wear all contribute to safer use of the Segway EPAMD.

e) The perception of the Segway as dangerous and the apprehensions prevalent in the minds of the selected candidates and the CEVEQ team faded away after one week's experimentation with driving the Segway and as the project progressed.

f) No incident or serious injury, nor any Segway/pedestrian collision or physical interference, was reported during either of the two phases of evaluation, where distances totalling more than 9,000 km were covered. The only incidents reported involved the user only. The frequency of such incidents may diminish as users gain driving experience.

g) During testing under actual operating conditions, in Phase 2, it was found that a significant distinction needs to be made between safety aspects and those concerning the EPAMD's acceptability.

h) The feeling of insecurity expressed by users generally arose from their lack of confidence in being able to properly control the device under difficult conditions, such as when encountering a pedestrian or navigating tight spaces and difficult surfaces, conditions which often exist on sidewalks. Most likely, with more driving experience, their confidence will improve, as when learning to ride a bicycle.

i) Among interactors, and in particular in the case of pedestrians on sidewalks, perceptions were a blend of safety concerns and the nuisance factor. The latter seems to be a greater concern than safety, since no incident or serious injury was reported in the course of 9,000 km of testing by users with little driving experience. The level of nuisance perceived was most probably exacerbated by the exceptionally large number of Segways and pedestrians that were interacting. Under normal operating conditions, the nuisance factor should diminish significantly.

j) EPAMDs being driven on sidewalks, cycle paths and road shoulders where speed is limited to 50 km/h will have little impact on user safety and still less on the safety of pedestrians, cyclists, motorists and other pedestrian route users.

4.2 ACCEPTABILITY

Sidewalks were the only type of pedestrian route where the acceptability of EPAMDs was at all in question. EPAMD traffic was found quite acceptable on cycle paths and roadway shoulders.

4.3 STANDARDS OF USE

a) The manufacturer's recommendation is that 16 be the minimum age required for use of this EPAMD on public roadways.

b) Most users perceive helmets to be necessary for safety. They should, therefore, be required.

c) Considering that Segway driver training involves about the same degree of complexity as learning to ride a bicycle and that the manufacturer, through its distributors, ensures that first-time purchasers receive a 30-minute initiation, formal training does not seem necessary.

d) Study limitations prevented night use of EPAMDs from being properly evaluated. Users' experience nonetheless suggested that under such conditions, EPAMDs would be as safe as bicycles as long as they were fitted with a headlight.

4.4 EPAMDS AS AN ALTERNATIVE VEHICLE

a) There was quite a bit of interest in Segways for short trips in urban settings; this would generate a certain amount of modal shifts, particularly from automobiles. At the current price of the Segway device, however, few of the users surveyed were ready to buy one.

5. RECOMMENDATIONS

a) Considering the Segway's very positive environmental qualities and insignificant negative impacts, apart from its possible nuisance value on sidewalks, its use on urban pedestrian routes should be allowed subject to regulations patterned after the suggested traffic standards.

b) Municipal authorities should be authorized to limit Segway traffic in areas or during periods they deem inappropriate.

c) Guidelines should be prepared for municipalities to inform them of measures to be taken to promote safe and trouble-free EPAMD traffic within their boundaries.

d) A public awareness campaign should be undertaken to allay fears and apprehensions among pedestrians with respect to EPAMD use on sidewalks and to promote the environmental benefits of their use.

e) Information on the rules of use for Segway drivers should be made available.

f) Canadian and US experience in the use of Segways should be monitored and standards of use adjusted accordingly.

6. DOCUMENTATION

References

1. Fly-Trottel Project 1. *Pilot project for evaluating motorized personal transportation devices: Segways and electric scooters,* TP 14285E, Final report, May 2004, CEVEQ.
2. *Test report.* Segway evaluation by the PMG Technologies Test and Research Centre.
3. *Ergonomic study of the Segway*, SHUMAC.
4. *Motorized Personal Transportation Devices (MPTDs).* Literature Review: Projects, Regulatory Frameworks and Safety Aspects. CEVEQ.
5. *Basic Rider Optimization Training for the Segway Human Transporter-Participant Workbook*, Segway LLC.
6. *Piétons et conducteurs vigilants pour la vie*, SAAQ.
7. *Highway Capacity Manual* (HCM).

Websites of interest

- www.mto.gov.on.ca
- www.saaq.qc.ca
- www.segway.com

Appendices

Appendix 1 – User Questionnaire – Results

Level of knowledge

1.1 Before embarking on this test, what was your level of knowledge of the Segway?

- ❑ I had already done a test 14%
- ❑ I did some research on the device 15%
- ❑ I had vaguely heard of it 53%
- ❑ I didn't know the device at all 18%

Training

1.2 Do you think that the training session is absolutely necessary for riding a Segway safely?

❑ yes 93% ❑ no 7%

1.3 Do you consider that a 3-hour training session adequately familiarized you with the device?

❑ yes 92% ❑ no 8%

If not, how much longer would you need?

- ❑ 1 to 2 hours 66%
- ❑ 2 to 3 hours 11%
- ❑ 3 to 6 hours 22%
- ❑ more than 6 hours 0%

1.4 After the 3 hours of training, did you feel ready to ride?

❑ yes 95% ❑ no 5%

1.5 What is your assessment of the information given to you during your training?

	Poor	Acceptable	Average	Good	Excellent
On the EPAMD (System, operation)	2%	5%	5%	39%	49%
On use of the device	0%	1%	1%	39%	59%
Driving ethics	2%	3%	4%	39%	52%
Safety rules: pedestrians and cyclists	1%	6%	12%	33%	48%

1.6 How complex did you feel it was to learn to ride the Segway EPAMD?

	Very difficult	Difficult	Average	Easy	Very easy
Getting on	2%	3%	34%	40%	21%
Balancing	0%	2%	13%	52%	33%
Accelerating	1%	0%	5%	52%	41%
Decelerating	2%	0%	12%	50%	36%
Handling	0%	2%	27%	50%	21%
Reflexes	1%	2%	33%	48%	16%
Turning on and off	1%	2%	9%	43%	45%
Changing modes	0%	2%	9%	39%	50%
Control on slopes	1%	6%	19%	48%	26%
Obstacles	3%	8%	35%	40%	14%

Experience with the device

2.1 Did you have some apprehensions before getting on the device?

❑ yes 43% ❑ no 57%

2.2 If so, were they dispelled during your testing?

❑ yes 91% ❑ no 9%

2.3 In general, did you feel safe during your testing of the device?

❑ never 0%
❑ sometimes 4%
❑ often 51%
❑ always 45%

2.4 In general, how do you perceive the device's manoeuvrability?

❑ poor 1%
❑ acceptable 2%
❑ average 4%
❑ good 37%
❑ excellent 56%

2.5 More specifically, how would you characterize your sense of security during the following operations:

		Poor	Acceptable	Average	Good	Excellent
1	Getting on the Segway	1%	2%	4%	37%	56%
2	Getting off the Segway	1%	2%	3%	35%	59%
3	Standing	1%	0%	2%	20%	77%
4	Accelerating	1%	1%	1%	26%	71%
5	Slowing down and braking	1%	1%	4%	39%	55%
6	Turning	0%	4%	17%	53%	26%
7	Backing up	0%	1%	7%	32%	60%
8	Going downhill	2%	2%	9%	35%	52%
9	Going uphill	0%	1%	4%	39%	56%
10	Getting around obstacles	1%	2%	19%	42%	36%
11	Negotiating rough surfaces	1%	6%	24%	43%	26%
12	Reading the dashboard	3%	6%	10%	29%	52%
13	Loading or unloading objects	4%	8%	21%	40%	27%
14	Using the accessories	1%	1%	13%	37%	48%
15	Getting onto sidewalks	2%	10%	15%	41%	32%
16	Getting off sidewalks	1%	6%	12%	42%	39%
17	Riding on sidewalks	6%	8%	22%	34%	30%
18	Riding on shoulders	2%	3%	11%	34%	50%
19	Crossing the street (intersections)	1%	2%	9%	31%	57%
20	Riding on bicycle paths	0%	1%	2%	19%	78%
21	Taking the vehicle up stairways	2%	8%	21%	40%	29%
22	Taking the vehicle down stairways	1%	7%	22%	42%	28%
23	Transporting the vehicle (e.g., in a car)	21%	17%	24%	22%	16%

2.6 At any point in your testing did you have the impression you were not completely in control of the device?

- ❑ never 42%
- ❑ sometimes 53%
- ❑ often 4%
- ❑ always 1%

2.7 Do you find that the Segway is sufficiently stable when stopped?

❑ yes 99% ❑ no 1%

2.8 Which of the following should be mandatory for users of the Segway EPAMD?

- ❑ Recognized training 65%
- ❑ Driver's licence 27%
- ❑ Wearing a protective helmet 71%
- ❑ Time of use 81%
  (prohibit evening and/or night-time use)
- ❑ Age limit 86%
  - ❑ 12 and up 11%
  - ❑ 14 and up 24%
  - ❑ 16 and up 46%
  - ❑ 18 and up 19%

2.9 How do you evaluate the overall performance of the Segway EPAMD?

	Poor	Acceptable	Average	Good	Excellent
Speed	4%	9%	20%	43%	24%
Range	27%	18%	20%	24%	11%
Responsiveness to controls	1%	2%	6%	40%	51%
Vehicle power	2%	5%	11%	46%	36%
Manoeuvrability	2%	1%	8%	42%	47%
Comfort	3%	9%	26%	37%	25%
Braking	2%	2%	12%	48%	36%
Accelerating	0%	2%	6%	48%	44%
Toughness / reliability	1%	2%	14%	49%	34%

SIDEWALKS

3. A In your riding experience ON SIDEWALKS specifically, please indicate what factors affected your sense of security, from the following choices:

Time of day	Congestion	Speed too high	Poor control	Impaired visibility	Disturbance to other users	Other	Nil
Day	3.1 Not crowded	12%	10%	2%	12%	5%	61%
	3.2 Crowded	7%	8%	6%	25%	2%	60%
Evening / night	3.3 Not crowded	5%	5%	11%	11%	5%	66%
	3.4 Crowded	5%	4%	10%	11%	2%	72%

3.B Indicate how easily you were able to do the following (specify day / evening):

		DAY				NIGHT			
		Difficult	Fairly easy	Easy	N.A.	Difficult	Fairly easy	Easy	N.A.
3.5	Getting onto a sidewalk without a curb cut	31%	21%	34%	14%	26%	17%	31%	26%
3.6	Getting onto a sidewalk with a curb cut	0%	16%	82%	2%	0%	18%	67%	15%
3.7	Crossing sloping areas	2%	32%	65%	1%	2%	30%	52%	16%
3.8	Overtaking a pedestrian or pedestrians	17%	31%	51%	1%	15%	30%	39%	16%
3.9	Getting around stationary obstacles	3%	32%	63%	2%	5%	31%	46%	18%
3.10	Crossing earth- or sand-covered surfaces	4%	30%	62%	4%	5%	28%	47%	20%
3.11	Crossing cracked surfaces (small holes)	10%	31%	57%	2%	12%	28%	43%	17%
3.12	Crossing the street at pedestrian crossings	3%	17%	79%	1%	1%	17%	66%	16%
3.13	Climbing slopes	2%	17%	79%	2%	0%	12%	71%	17%
3.14	Going down slopes	3%	16%	78%	3%	1%	18%	63%	18%
3.15	Remaining on the sidewalk at all times	24%	28%	45%	3%	24%	27%	30%	19%

* N.A.: Not applicable

BICYCLE PATHS

4. A In your riding experience ON BICYCLE PATHS specifically, please indicate what factors affected your sense of security, from the following choices:

Time of day	Congestion	Speed too high	Poor control	Impaired visibility	Disturbance to other users	Other	Nil
Day	4.1 Not crowded	2%	3%	2%	2%	2%	91%
	4.2 Crowded	1%	2%	2%	4%	1%	92%
Evening / night	4.3 Not crowded	0%	1%	6%	2%	2%	90%
	4.4 Crowded	1%	1%	5%	2%	1%	92%

4.B Indicate how easily you were able to do the following (specify day / evening):

		DAY				NIGHT			
		Difficult	Fairly easy	Easy	N.A.	Difficult	Fairly easy	Easy	N.A.
4.5	Making your presence known (horn, light, etc.)	16%	10%	42%	32%	14%	7%	29%	50%
4.6	Avoiding or overtaking a cyclist or cyclists	4%	20%	55%	21%	4%	16%	36%	44%
4.7	Getting past access barriers	3%	26%	49%	22%	3%	21%	31%	45%
4.8	Overtaking a pedestrian or pedestrians	4%	17%	62%	17%	4%	17%	38%	41%
4.9	Getting around stationary obstacles	0%	14%	68%	18%	2%	10%	46%	42%
4.10	Crossing earth- or sand-covered surfaces	2%	18%	56%	24%	3%	18%	35%	44%
4.11	Crossing cracked surfaces (small holes)	3%	19%	60%	18%	2%	19%	40%	39%
4.12	Crossing the street at intersections	1%	9%	74%	16%	1%	7%	51%	41%
4.13	Climbing slopes	1%	8%	74%	17%	1%	8%	49%	42%
4.14	Going down slopes	1%	11%	70%	18%	2%	12%	45%	41%
4.15	Remaining on the bicycle path at all times	2%	11%	77%	10%	3%	8%	50%	39%

* N.A.: Not applicable

SHOULDERS

5. A In your riding experience ON SHOULDERS specifically, please indicate what factors affected your sense of security, from the following choices:

Time of day	Congestion	Speed too high	Poor control	Impaired visibility	Disturbance to other users	Other	Nil
Day	5.1 Not crowded	4%	2%	2%	3%	3%	85%
	5.2 Crowded	4%	2%	2%	5%	3%	86%
Evening / night	5.3 Not crowded	2%	2%	7%	1%	5%	86%
	5.4 Crowded	2%	2%	8%	3%	2%	85%

5.B Indicate how easily you were able to do the following (specify day / evening):

		DAY				NIGHT			
		Difficult	Fairly easy	Easy	N.A.	Difficult	Fairly easy	Easy	N.A.
5.5	Making your presence known to motorists	19%	27%	34%	20%	26%	13%	18%	43%
5.6	Avoiding or overtaking a cyclist or cyclists	5%	21%	42%	32%	6%	15%	28%	51%
5.7	Keeping space between you and the cars	3%	30%	43%	24%	3%	20%	29%	48%
5.8	Overtaking a pedestrian or pedestrians	9%	19%	48%	24%	9%	9%	33%	49%
5.9	Getting around stationary obstacles	5%	21%	54%	20%	3%	17%	35%	45%
5.10	Crossing gravel or dirt surfaces	4%	25%	45%	26%	4%	16%	30%	50%
5.11	Crossing uneven surfaces	1%	31%	48%	20%	4%	19%	33%	49%
5.12	Crossing the street at intersections	2%	13%	68%	17%	1%	13%	44%	42%
5.13	Climbing slopes	1%	13%	66%	20%	1%	9%	46%	44%
5.14	Going down slopes	0%	17%	63%	20%	1%	14%	40%	45%
5.15	Remaining on the shoulder at all times	9%	16%	53%	22%	6%	13%	35%	46%

Laval (Questions added by the Laval authorities – Results for 48 Laval users)

5.16 Where there were no sidewalks, how often did you leave the shoulder and use the roadway (street) to get around an obstacle or a car?

0-5 times:	25%
6-10 times:	15%
11-15 times:	4%
16+ times:	5%
a few times:	4%
often:	47%

5.17 Had you been on foot, would you have gone around the obstacle the same way?

❑ yes 70% ❑ no 30%

Overall assessment

6.1 In your experience, what factor(s) are most dangerous in interactions with pedestrians, cyclists and motorists?

	Pedestrian	Cyclist	Motorist
Speed	50%	15%	24%
Visibility	16%	22%	32%
Congestion	22%	7%	11%
Control/manoeuvrability	28%	18%	18%
Curiosity	40%	32%	42%
Nil	5%	9%	6%

6.2 Would you recommend that a speed limit be imposed on sidewalks?

yes 47% no 53%

< 5 km/h	5%
6-10 km/h	54%
11-15 km/h	24%
16-20 km/h	12%
> 20 km/h	5%

6.3 Did you try the vehicle in the rain?

yes 41% no 59%

If so, did you feel safe using it in the rain?

yes 87% no 13%

6.4 In your experience, what aspects of the traffic environment caused you difficulties?

	Never	Sometimes	Often	Always
Cracks in the sidewalk	26%	49%	20%	5%
Bumps	27%	58%	13%	2%
Potholes	26%	49%	21%	4%
Gutters	62%	27%	10%	1%
Puddles	76%	23%	1%	0%
Fire hydrants	91%	7%	2%	0%
Rain	84%	15%	1%	0%
Wind	83%	15%	2%	0%
Insects	87%	13%	0%	0%
Tree branches	50%	43%	7%	0%
Car doors	75%	22%	3%	0%
Animals	89%	10%	1%	0%
Refuse	64%	29%	7%	0%
Soft surfaces (grass, gravel, ...)	62%	34%	3%	1%
Other	57%	28%	10%	5%

6.5 How was your riding divided by time of day (/100%)?

Day	0-25%: **13%** 26-50%: **22%** 51-75%: **17%** 76-100%: **48%**
Evening	0-25%: **65%** 26-50%: **25%** 51-75%: **6%** 76-100%: **5%**
Night	0-25%: **95%** 26-50%: **3%** 51-75%: **1%** 76-100%: **1%**

6.6 Did you use the accessories?

	Never	Sometines	Often	Always
Light	51%	25%	19%	5%
Horn	73%	20%	7%	0%

6.7 If you used them, how satisfied were you with the accessories?

	Dissatisfied	Satisfied	Very satisfied
Light	23%	56%	21%
Horn	53%	28%	19%

7.1 Did you enjoy this experience?

❑ yes **98%** ❑ no **2%**

7.2 Which of the following statements do you feel best sums up your conception of the Segway EPAMD?

- ❑ It is a new means of personal transportation that will meet specific needs for getting around the city **61%**
- ❑ It is especially suited to moving around in a closed environment **22%**
- ❑ It will primarily be useful to mobility-impaired persons **9%**
- ❑ It is basically a gadget (toy) **15%**
- ❑ It is a revolutionary means of transportation **21%**
- ❑ NONE of the above **2%**

7.3 Would you be interested in using the device in various environments?
(More than one answer is possible)

- ❑ Inside a building **74%**
- ❑ In a park **67%**
- ❑ On a bicycle path **72%**
- ❑ On sidewalks **50%**
- ❑ Inside an industrial or private space **83%**
- ❑ Inside a shopping centre **50%**
- ❑ In the subway **23%**

7.4 Following your testing, how do you assess the Segway EPAMD against the following criteria:

	Good	Average	Needs improvement
Overall performance	73%	15%	12%
Manoeuvrability	87%	11%	2%
Ease of use	86%	11%	3%
Weight	29%	37%	34%
Sense of security	72%	21%	7%

7.5 Would you possibly be interested in buying a Segway EPAMD?

❑ yes **55%** ❑ no **45%**

7.6 What would you be willing to pay for it?

❑ Less than $2,000	**80%**
❑ $2,000–3,500	**17%**
❑ $3,500–5,000	**4%**
❑ more than 5000$	**0%**

7.7 Do you see one or more applications in your day-to-day life for a Segway EPAMD?

❑ Commuting to work	**55%**
❑ Recreation	**52%**
❑ Shopping	**52%**
❑ Riding around the neighbourhood	**65%**
❑ None	**10%**

7.8 Is the Segway EPAMD compatible (complementary) with other means of transportation?

❑ yes **81%** ❑ no **19%**

7.8.1 If so, which ones?

❑ Automobile	**45%**
❑ Bus	**34%**
❑ Bicycle	**53%**
❑ Walking	**51%**
❑ Train	**19%**
❑ Taxi	**16%**
❑ None	**3%**

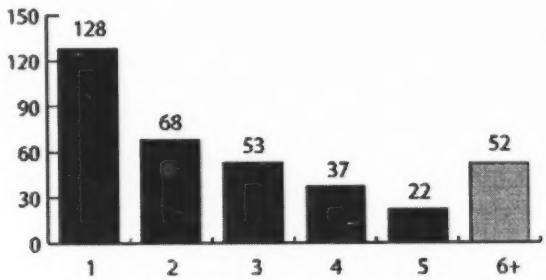
7.9 What do you see as the applications for a Segway EPAMD?

❑ Police	**49%**
❑ Letter carrier	**72%**
❑ Personal use	**75%**
❑ Industrial use	**83%**

Appendix 2 - User Questionnaire - Results

Question 1: During the last hour, did you meet one or more Segways?
During the interaction periods, the very great majority of respondents (98%) had met one or more Segways during the past hour. Since the survey was done at a time when there was a massive concentration of users, the results confirm the effectiveness of that approach. Thus, 64% of respondents had met more than two Segways, whereas 36% had seen just one.

1 – During the last hour, did you meet one or more segways?



1.1 – If so, how many times?

Question 2: Did the Segway(s) get in your way at all?

In response to this question, the very great majority of respondents (95%) said that the Segway(s) they had met had not got in their way at all, while a tiny minority (5%) said they had.

2 – Did the Segway get in your way at all?

Question 3: Did you ever have to change course because of a Segway?

Most respondents (89%) did not have to change course when they met one or more Segways, though 11% said they had been obliged to do so.

3 – Did you ever have to change course because of a Segway?

Question 4: Did the Segway rider place you in a dangerous situation?

The response to this question was nearly unanimous: 99% of respondents considered that the Segway rider had not endangered them.

4 – Did the Segway rider place you in a dangerous situation?

Question 5: At intersections, do you think the Segway may pose more of a threat than a pedestrian?

The majority of respondents (86%) say the Segway is no more dangerous than a pedestrian, but 14% think it is.

5 – At intersections, do you think the Segway may pose more of a threat than a pedestrian?

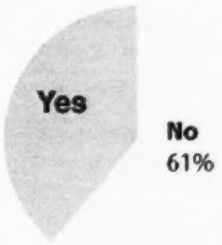
Question 6: On shoulders, do you think the Segway may pose more of a threat than a pedestrian?

Seventy-six percent of respondents say the Segway is no more dangerous than a pedestrian, but almost one quarter of them think it is.

6 – On shoulders, do you think the Segway may pose more of a threat than a pedestrian?

Question 7: On sidewalks, do you think the Segway may pose more of a threat than a pedestrian?

The response to this question was more divided, as 61% of respondents felt the Segway did not pose a danger on sidewalks, but 39% thought it did.



7 – On sidewalks, do you think the Segway may pose more of a threat than a pedestrian?

Question 8: In your experience, do these devices go too fast?

The Segway does not go too fast. according to 87% of the respondents, while 13% say it does.

8 – In your experience, do these devices go too fast?

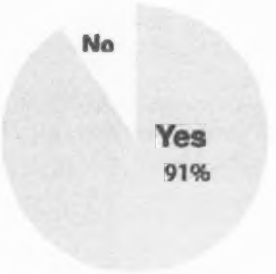
Question 9: Do you think the sidewalk is a suitable place for these devices?

The answer to this question is similar to that for No. 7: 59% of respondents think the sidewalk is a good place for the Segway, while 41% say it isn't.

9 – Do you think the sidewalk is a suitable place for these devices?

Question 10: Do you think the bicycle path is a suitable place for these devices?

A majority of respondents (91%) believe the Segway is well suited to a bicycle path, whereas 9% think it isn't.



10 – Do you think the bicycle path is a suitable place for these devices?

Question 11: Do you think the shoulder is a suitable place for these devices?

On this question, 71% of respondents said Segways were well suited to the shoulder, while 29% thought they weren't.

11 – Do you think the shoulder is a suitable place for these devices?

Appendix 3 – Questionnaire - Police reports

City / Borough: _____
Official's name: _____
Report date: _____

Incidents

1 – Place

During the four weeks of Segway EPAMD testing in your municipality, were any incidents reported regarding the devices' use on:

	YES	NO	Comments
A - Sidewalks?			
B – Bicycle paths?			
C – Shoulders?			

2 – Time of day

If incidents were reported, did they occur at a specific time of day?

A – Frequency of daytime incidents _____%
B – Frequency of evening/ nighttime incidents _____%

Comments on incidents (please attach the incident reports)

3 – Compliance with instructions

During the testing period, is it your judgement that EPAMD users complied with the instructions they were given (to act like a pedestrian)?

Instruction	YES	NO	Frequency
A – Helmet			
B – Crossings			
C – Facing traffic			
D – Light (evening)			

Comments on instructions:
Riding outside the designated area.

4 – Overall assessment

4.1 From the police viewpoint, can EPAMD use pose a danger to other users of pedestrian routes?

YES ☐ NO ☐ Explain

Due to the SEGWAY's speed, which can surprise pedestrians.

4.2 Did you receive any citizen complaints about the EPAMDs during the testing period? If so, give particulars.

YES ☐ NO ☐ Explain

5 – Comments